Small or medium-scale focused research project (STREP) proposal

ICT Call 5

FP7-ICT-2009-5

PART B

Managed Ecosystems of Networked Objects

MENO

Work programme topic(s) addressed:
Challenge 1: Pervasive and Trustworthy Network and Service Infrastructures
Objective ICT-2009.1.1: The Network of the Future
  a) Future Internet Architectures and Network Technologies

Date of preparation: October 12, 2009
Name of the coordinating person: Ingrid Moerman
E-mail: ingrid.moerman@intec.ugent.be
Fax: +32 9 33 14899

List of participants:

<table>
<thead>
<tr>
<th>Participant No.</th>
<th>Participant Organisation Name</th>
<th>Part. Short Name</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Coordinator)</td>
<td>Interdisciplinary Institute for Broadband Technology</td>
<td>IBBT</td>
<td>Belgium</td>
</tr>
<tr>
<td>2</td>
<td>JCP-Consult SAS</td>
<td>JCP-Consult</td>
<td>France</td>
</tr>
<tr>
<td>3</td>
<td>Technical Research Centre Of Finland</td>
<td>VTT</td>
<td>Finland</td>
</tr>
<tr>
<td>4</td>
<td>Universidad De Cantabria</td>
<td>UC</td>
<td>Spain</td>
</tr>
<tr>
<td>5</td>
<td>NEC Europe LTD</td>
<td>NEC</td>
<td>UK</td>
</tr>
<tr>
<td>6</td>
<td>RMoni Wireless NV</td>
<td>RMoni</td>
<td>Belgium</td>
</tr>
<tr>
<td>7</td>
<td>Lagassé Technologies</td>
<td>LT</td>
<td>France</td>
</tr>
</tbody>
</table>
Proposal abstract

The combination of network virtualization, clean-slate protocol design for sensor data access and usage and the integration of cloud computing, represents the innovative core of this project and is captured in the concept of Managed Ecosystems of Networked Objects (MENO).

MENO believes that sensors networks will become a cornerstone of the Future Internet, enabling many novel services. To achieve this, sensor nodes should be seamlessly integrated, which is not possible today due to the structural limitations of the Internet. Sensor networks are now seen as an add-on, by implementing gateways, which limits flexibility in deployment, usage and the advent of novel services. Further, seamless integration does not mean opening up access to sensor data to the whole world. Many scenarios require restricted and secure access to distributed sensor data, involving only a limited group of devices that need to collaborate.

MENO will address these problems by creating secure virtual environments of all involved parties in an automatic fashion in order to offer secure and restricted access to sensors. On top of this virtual network, a seamless integration will be achieved through the design of a well-chosen set of novel clean-slate end-to-end protocols for sensor data discovery and access, together forming an ecosystem. From the start of our design, we hereby take into account the specific limitations and characteristics of the most limited end devices. Finally, MENO will integrate cloud resources into this ecosystem, offering a flexible and scalable solution to be able to collect, store, process and enrich the huge amount of data that can be generated, not possible with traditional computing devices.

MENO’s final objective is to realize an end-to-end system, demonstrating the feasibility, flexibility and advantages of this concept for a specific application scenario and will as such contribute to an increased sensor node usage and their integration in the Future Internet.
# Table of contents

1 **Scientific and/or technical quality, relevant to the topics addressed by the call** ...............6
   1.1 Concept and objectives .............................................................................................................6
   1.1.1 Concept .................................................................................................................................6
   1.1.2 S&T Objectives ..................................................................................................................9
   1.1.3 Relation of Objectives to Call Topics ..................................................................................13
1.2 Progress beyond the state-of-the-art .......................................................................................15
   1.2.1 Today’s communication between sensor nodes and IP devices ....................................15
   1.2.2 Network virtualization and the integration of sensor nodes .............................................17
   1.2.3 Cloud computing ...............................................................................................................19
   1.2.4 Development frameworks ..................................................................................................19
   1.2.5 Relevant Future Internet activities and projects .................................................................20
   1.2.6 Demonstration ...................................................................................................................21
   1.2.7 Overall conclusion .............................................................................................................22
1.3 S/T methodology and associated work plan ..........................................................................23
   1.3.1 Work plan .............................................................................................................................23
   1.3.2 Project planning ....................................................................................................................24
   1.3.3 Work description ................................................................................................................25
   1.3.4 Project flow ..........................................................................................................................47
   1.3.5 Risks and contingency plans ...............................................................................................48
2 **Implementation** ....................................................................................................................50
   2.1 Management structure and procedures ...............................................................................50
   2.1.1 Management structure and decision-making structure ...................................................50
   2.1.2 Management roles .............................................................................................................54
   2.1.3 Operations and communication tools .............................................................................54
   2.1.4 Monitoring, reporting progress and documenting results .............................................55
   2.2 Individual participants ..........................................................................................................56
   2.3 Consortium as a whole ..........................................................................................................63
2.4 Resources to be committed .............................................................. 68

2.4.1 Overall budget ............................................................................. 68

2.4.2 Other major costs .......................................................................... 69

2.4.3 Mobilisation of the resources ......................................................... 70

3 Impact .................................................................................................... 71

3.1 Expected impacts listed in the work programme .................................. 71

3.1.1 Expected impact ........................................................................... 71

3.1.2 Strategy for impact achievement ................................................... 75

3.1.3 European dimension ...................................................................... 75

3.1.4 Other relevant European or National funded research .................... 76

3.1.5 Influence of external factors .......................................................... 76

3.2 Dissemination and/or exploitation of project results, and management of intellectual property.......................................................... 76

3.2.1 Exploitation and dissemination plan for use of project results .......... 76

3.2.2 Management of knowledge and intellectual property ..................... 80

4 Ethical Issues ........................................................................................... 82

5 References ............................................................................................... 83
Figures

Figure 1: MENO concept ................................................................. 8
Figure 2: MENO objectives ............................................................ 9
Figure 3: Background experience on virtual networks ......................... 18
Figure 4: Effort breakdown per work package ................................... 46
Figure 5: Effort breakdown per partner ........................................... 46
Figure 6: Project Flow ................................................................... 47
Figure 7: Management Structure .................................................... 51
Figure 8: Overall budget overview ................................................... 66
Figure 9: Geographical location ....................................................... 66
Figure 10: Budget versus country ..................................................... 67
Figure 11: Effort breakdown per activity ........................................... 68
Figure 12: M2M development by vertical industry (source IDATE 2008) ......................... 71

Tables

Table 1: Example application scenarios ........................................... 9
Table 2: Target outcome of MENO towards objective ICT-2009.1.1, target outcome a) .......... 13
Table 3: Summary effort table ......................................................... 46
Table 4: Work package leadership ................................................... 53
Table 5: Scientific and technological excellence and skills .................... 63
Table 6: Partners skills versus objectives ........................................... 64
Table 7: MENO Budget ................................................................. 68
Table 8: Other major costs ............................................................. 69
Table 9: MENO and relevant standardisation groups and organisations ......................... 74
Table 10: Ethical Issues table .......................................................... 82
1 Scientific and/or technical quality, relevant to the topics addressed by the call

1.1 Concept and objectives

1.1.1 Concept

The combination of network virtualization, clean-slate protocol design for sensor data access and usage and the integration of cloud computing, summarizes the innovative core of this project and is captured in the more general concept called Managed Ecosystems of Networked Objects (MENO). To understand the main ideas that led to this concept, we first need to look at today’s communication with sensor nodes and the demands imposed by application scenarios.

Today, sensor nodes are gradually connected to the Internet via dedicated vendor-specific gateways, making access to sensor data possible through specifically implemented functionality in the gateway. The use of a dedicated gateway has certain advantages. Most importantly, the gateway represents a single dedicated point of communication, configuration and access control and is as such, for a single vendor, the easiest way to bring their sensor applications to the market. However, the use of dedicated gateways has several limitations and disadvantages, which will become more prevalent with the increase of new sensor nodes, their distribution over different geographical locations and the flexibility people desire in the future for integrating sensor knowledge in their applications. The following presents a number of these limitations or disadvantages:

- Protocol translation: the gateway translates the sensor network protocols to IP protocols and vice versa. This means that for every sensor application, the gateway must implement the appropriate translation functionality. Adding a new type of sensor node requires an upgrade of the gateway. Also, since the gateway is the only one that can directly see the sensor data, the gateway represents the only place where intelligent decisions or operations on the data can be executed. Intelligence cannot be placed in the protocols or in the application endpoints in the IP world.

- Complexity for application developers: an application developer that wants to make use of sensor data, has to implement the vendor-specific API offered by the gateway and is limited by this interface. Interacting with gateways of different vendors or with gateways at different locations, increases complexity when developing applications and reduces the speed and flexibility of designing novel applications.

- Vendor lock-in: sensor nodes from a specific vendor require a gateway from the same vendor. This limits customer flexibility, since the number of gateways increases with the number of vendors from whom sensor nodes are purchased, forcing customers to stick with the same vendor. In addition, it also makes the entrance for young startups to the sensor market more difficult, since they are always tied to the combination sensor + gateway, the only viable market model today.

- Sensor node distribution and mobility: deploying sensor nodes at different geographical locations requires the installation and configuration of multiple gateways and the awareness of this by the applications using sensor data. Further, since sensor nodes are bound to a specific gateway, they cannot easily migrate from one gateway to another.

It is envisioned that sensors networks will become a cornerstone of the Future Internet, enabling plenty of new services and giving added value to traditional services. In order to fully unleash their potential, a seamless integration of these sensor networks within today’s IP-based and tomorrow’s Internet is required. Seeing sensor networks just as an add-on, e.g. by implementing gateways, will always limit flexibility in deployment and will degrade performance as has been shown in the above list with limitations and disadvantages. Therefore, easy deployment, end-to-end connectivity, protocols and sensor data usage are some of the main targets to strive for.

To reach these objectives the following considerations need to be taken into account. Although the Internet connects everything to everything, in several important scenarios (today and in the future) its service usage only involves a limited set of devices. In scenarios such as transport networks, site monitoring, Personal Networks... (Which are elaborated further on), restricted and secure access to
distributed (and/or mobile) sensor data is required. Opening up access to sensor data to the whole world is not desirable, nor is centrally controlling all access. As such, communication and service consumption will often be confined within a limited environment consisting of sensor nodes and other networked objects such as laptops, mobile phones or virtualized machines or resources in a cloud. The creation of a secure virtual environment of the involved parties in a distributed and automatic fashion is an interesting solution to offer this secure and restricted access to sensors. This allows secure interaction between sensors and other networked objects. This approach is also in line with ongoing efforts related to network virtualization, which are targeted to provide flexibility, promote diversity and promise increased manageability and security in the Future Internet. However, so far these efforts have always excluded sensor nodes, as these have not been considered as an integral part of the Internet.

Moreover, such a virtual environment creates a playground in which novel clean-slate end-to-end protocols can be developed and deployed tailored to the characteristics of the devices and data flows, which are strongly different from the characteristics encountered in today’s IP world. IP and its higher layer protocols succeeded in solving the interconnection and interoperability issues of different networks. However, taking into account the advent of lightweight devices such as sensor nodes, it is clear that the standard IP protocols (e.g. IP, TCP, HTTP…) are too heavy for these devices and have been developed with a completely different mindset. In addition, a lightweight version of them is also not the best design approach, since real end-to-end connectivity and easy sensor data access and usage impose totally different requirements than those that have been used so far. To overcome these structural limitations, a clean-slate design approach is needed within this virtual environment and this virtual environment perfectly offers everything that is needed to introduce such disruptive technologies independent from the limitations of the existing Internet and achieve a seamless integration of these sensor nodes.

First of all, the efficient and intelligent distribution of sensor data within a virtual environment that consists of very heterogeneous devices requires novel addressing, unicast/multicast, transport and data processing capabilities. For example, looking at how sensor data is distributed, multicast must be a fundamental part of the design and not an add-on on top of unicast functionality. Also, the efficient propagation of sensor data can benefit from intelligent processing in the more powerful devices. Next to this, it is of utmost importance to come up with completely new primitives for application developers in order for them to use sensor data in a natural way and without bothering about sockets, ports… For example, automatic discovery must allow them to discover the sensors present in the virtual environment and the functionality they offer, similar to what is possible today with plug-and-play devices in LAN type networks. (e.g. UPnP, Bonjour…). User friendly naming of sensor nodes, sensor data types or groups of sensor nodes must give application developers a means to flexible talk to sensor directly and to retrieve and use their data (e.g. built-in function calls such as “temperature.home,10” should be sufficient to retrieve the temperature of all temperature sensor nodes at home every 10 minutes). Including such flexibility requires a completely new design approach, not tackled by ongoing projects. The approach of grouping devices into a virtual environment allows taking such a design approach, opening up new possibilities for designing novel end-to-end connectivity and easy sensor data access and usage and taking the fundamental characteristics of the devices and the data flows into account.

This leaves us with a last problem. Depending on the scenario or during time, the gathering, storage and processing of sensor data can greatly vary in required processing capabilities and storage requirements, putting severe stress on traditional computing devices such as PCs, which have not been designed to scale accordingly. Also, the collected data sometimes needs to be enriched with input from external services or the users in the virtual environment want to offer a subset of the collected and processed data as a service to users outside the virtual environment. By integrating cloud computing into this virtual environment, a solution can be offered to these problems.

Cloud computing is a paradigm of computing in which dynamically scalable and often virtualized resources are offered as a service over the Internet, without requiring technical expertise from the users. As such, when innovatively combining them with the proposed virtual environments and the clean-slate protocols, the following can be realized. By bringing resources from the cloud into the proposed secure virtual environment, these resources can make use of the clean-slate protocols, to easily gather the sensor data from several locations in the virtual environment, while benefitting from the security and self-organization of the virtual environment. According to the users’ needs, these
resources take care of the computing and processing in a very flexible way, due to their inherent nature to automatically scale according to the needs. In addition, the cloud resources brought into the virtual environment, can offer a service through which the collected and processed data can be offered in a controlled way to external partners, establishing interaction with the outside world where it can be used to create novel applications and services.

The above ideas and observations, have led to the combination of network virtualization, clean-slate protocol design for sensor data access and usage and the integration of cloud computing, representing the core of this project. This has been captured in the general concept of Managed Ecosystems of Networked Objects. Such an ecosystem is defined as a completely independent, managed, observable, virtual environment of interdependent, networked objects that cooperate in harmony.

- Objects: any device that can communicate, ranging from lightweight embedded sensor nodes over powerful IP devices to virtualized machines and cloud resources, with a key role for sensor nodes and cloud resources
- Interdependent: all objects rely on each other for a common goal and as such represent a logical grouping
- In harmony: seamless, end-to-end operation, requiring a clean slate design from networking to application API
- Virtual environment: objects can be physically distributed, but form one logical network through network virtualization
- Completely independent: can fulfil its function without the need for any interaction with the outside world and is protected from this outside world
- Managed: flexible creation and control of ecosystems
- Observable: properties of the ecosystem can be exposed to the outside world in order to offer services to the outside world

![Figure 1: MENO concept](image)

**Target scenarios**

The following table briefly summarizes 3 relevant scenarios that can be perfectly mapped onto the proposed MENO concept and that give an idea of the potential use cases.
Table 1: Example application scenarios

<table>
<thead>
<tr>
<th>End consumer scenario</th>
<th>Business scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Home scenario</strong></td>
<td><strong>Transport scenario</strong></td>
</tr>
<tr>
<td>• Home equipped with sensor nodes (HVAC, fire detection, cameras)</td>
<td>• Monitoring of trucks of a transport company, equipped with different sensors (camera, temperature, pollution…)</td>
</tr>
<tr>
<td>• In ecosystem with other user devices</td>
<td>• Trucks in ecosystem</td>
</tr>
<tr>
<td>• Direct access to sensor data from wherever you are</td>
<td>• Collection of sensor data via ecosystem</td>
</tr>
<tr>
<td>• Sensors from different vendors</td>
<td>• Storage and processing in cloud</td>
</tr>
<tr>
<td>• Storage and processing by cloud resources</td>
<td>• Enrichment of data</td>
</tr>
</tbody>
</table>

1.1.2 S&T Objectives

MENO will combine network virtualization, clean-slate protocol design for sensor data access and usage and cloud computing and will realize this through a clear set of well-defined, achievable S&T objectives, which can be broadly classified in the following three major components.

- **The creation and management of the ecosystem**, resulting in a virtual environment in which a selected group of sensor nodes, IP devices and cloud resources are interconnected over virtual, secure links.
- The development of novel clean-slate end-to-end solutions on top of this interconnectivity. The interconnectivity offered, can be seen as a fresh new network on top of which any new protocol can be designed from scratch.
- The development of cloud computing and sensor services that enable the collection of sensor data from within the ecosystem using the clean-slate protocols and according to the needs of the users, enrich it where needed, act upon it and can export it in a controlled way to the outside world.

An overall view on the envisioned system is shown in Figure 2, representing the general design goals of the MENO project. For every component, we will now describe the detailed objectives.

![Figure 2: MENO objectives](image)

**Ecosystem creation and management**

In order to be able to create this ecosystem and to demonstrate a clean-slate design on real hardware, we will build our own virtual network on top of today’s Internet, since none of the existing virtualization efforts takes into account sensor nodes or only focuses on the virtualization of the Internet core. Therefore, we will start from our existing work on deploying virtual networks of IP-capable devices on top of layer 2 and the IP-based Internet (see section 1.2). Through this experience, we have learned to integrate IP-capable devices into a virtual IP network in which they can securely and transparently communicate using any existing IP based protocols. **Starting from this background knowledge on virtual networks**, the following list presents the focussed objectives that will be realized in order to
extend this baseline and to realize the virtual network environment offered by the ecosystem. The measurable output of these objectives will be a set of software building blocks, where every building must implement the functionality targeted by the corresponding objective. During design time and initial development time, this output will come in the form of reports describing the design specifications. For verification, 10 milestones for these objectives have been defined, which are also presented here for every related objective.

- **Enable the integration of trusted sensor nodes and cloud resources into the virtual environment** (both IP-capable sensor nodes and non-IP sensor nodes). For sensor nodes, this requires the ability to implement a lightweight trust relationship on these nodes to indicate their membership of the ecosystem. Next to this, also resources from the cloud must become part of the virtual environment, e.g. in the form of a virtual machine. **Milestone 3.2 (month 6)** presents the draft specification of solutions for adding these objects to the ecosystem, **milestone 3.5 (month 12)** represents a first software implementation of these solutions, **milestone 3.7 (month 17)** delivers an enhanced implementation and finally, **milestone 3.10 (month 24)** delivers the final version ready for integration in the demonstrator.

- **Enable the creation of virtual links with other members of the ecosystem over sensor network interfaces.** Here we will take into account the specific characteristics of sensor nodes such as sleep modes, maximum size of data that can be transmitted and the impact on the design of the virtual links. In addition, the hardware limitations (limited memory, processing power…) will put strict requirements on the possible solution space. **Milestone 3.3 (month 6)** describes the draft specification of solutions for establishing these virtual links, **milestone 3.5 (month 12)** represents a first software implementation of these solutions, **milestone 3.8 (month 17)** delivers an enhanced implementation and finally, **milestone 3.10 (month 24)** delivers the final version ready for integration.

- **Enable easy management of this environment.** A user-friendly management system is needed to add nodes to or revoke nodes from the ecosystem. Through this management system, which should be able to deal with devices that do not have a user interface, the trust relationship that indicates that a node is part of an ecosystem, must be installed. **Milestone 3.4 (month 6)** presents the draft specification of a management solution, **milestone 3.9 (month 20)** represents a first release of software components for ecosystem management and finally, **milestone 3.10 (month 24)** delivers the final version ready for integration.

- **Develop a lightweight convergence layer** towards the upper layers that hides the underlying virtual links. This will be realized in the form of a virtual adapter that gives access to other nodes in the ecosystem over the different virtual links that have been established. Using this adapter, datagrams can be sent to all virtual links (broadcast) or a single virtual link (unicast). In addition, link properties will be exposed to the upper layers in a standardized way, hereby hiding the heterogeneity of different link technologies. The design must be lightweight, since it must run on devices with limited capabilities. Joint **milestones 3.1 and 4.1 (month 3)** describe the draft specification of this virtual adapter, **milestone 3.5 (month 12)** represents a first software release of this adapter, joint **milestones 3.6 and 4.6 (month 14)** deliver an enhanced implementation and finally, **milestone 3.10 (month 24)** delivers the final version ready for integration.

By realizing the above objectives, a virtual environment that consists of both IP devices, including cloud resources, and sensor nodes will be designed, implemented and deployed, with a single interface to the upper layers on top of which any novel protocol can be deployed from scratch.

**Clean-slate end-to-end protocol design within the ecosystem**

As already stated, on top of the lightweight convergence layer, any new protocol can be developed and implemented from scratch. This approach enables a clean slate approach for the design of end-to-end solutions for communication between groups of sensor nodes and networked objects, tailored to the specific characteristics of the sensor nodes and the corresponding data flows, characteristics that are strongly different from the characteristics encountered in today’s IP world. The project’s efforts will focus on 2 major objectives:
1. Efficient and intelligent distribution of sensor data

The characteristics of the sensor nodes and the corresponding data flows will be studied, based on a number of selected scenarios and from that point on, requirements for the design of protocols for the efficient and intelligent distribution of sensor data will be designed. Of course, it is already clear that, when sensor nodes are included, multicast distribution of data will play a fundamental role in the distribution of data. Consequently, the following objectives need to be realized minimally to achieve this goal.

- **Design and implement an addressing scheme.** The lightweight convergence layer only offers a means to send data over virtual links through the adapter it offers. In order to allow data distribution, an addressing mechanism is needed to address individual nodes or groups of nodes. Since multicast is important, our addressing scheme will assign two addresses to every node: one unicast address that is used to address an individual node and a **dual address** (that can be derived from the unicast address) that can be used to address all nodes that are interested in the services of that node. As such, multicast functionality will be incorporated in the design already from the very beginning. Also, lightweight nodes only need to know two addresses, their own address and their dual address, indicating everyone that is interested in the data it offers.

- **Design and implement basic best-effort and reliable unicast and multicast data forwarding functionality.** Basic functionality to enable end-to-end unicast communication between two nodes in the ecosystem is needed, either in a reliable or best-effort way. Hereby, the limitations of the devices must be taken into account. In addition, the automatic creation of multicast trees and their binding to the proposed dual address is also needed in order to offer multicast functionality as a basic building block. This functionality is crucial, since often communication will be many-to-one or one-to-many.

Again, the ultimate measurable output of these objectives will be a set of software building blocks, where every building must implement the functionality targeted by the corresponding objective. During design time and initial development time, this output will come in the form of reports describing the design specifications. For both objectives, the following 4 milestones help verifying their achievement: **milestone 4.2 (month 7)** provides a draft specification of addressing, unicast and multicast solutions, **milestone 4.5 (month 14)** delivers a first version of the implementation of these solutions, resulting in an enhanced version at **milestone 4.8 (month 18)**, and finally **milestone 4.11 (month 24)** delivers the final version ready for integration in the demonstrator.

2. Naming, discovery and a flexible API for application developers

Next to the efficient and intelligent distribution of data, it is of utmost importance to come up with new primitives for application developers in order for them to use sensor data in a natural way and without bothering about sockets, ports… To realize this, the following objectives will be realized.

- **Design and implement a user-friendly naming system.** In the same way as DNS offers a user-friendly way to address IP machines in the Internet, a naming system is needed within our ecosystem. However, such a naming system should be able to do more than just being able to address individual members of the ecosystem. Next to naming individual nodes, it should allow addressing groups of nodes, types of sensor data… Such naming primitives are needed since they fit much better the way sensor data is retrieved and used. Also, the naming process should be automated as much as possible, not bothering users with the assignment of names. Finally, translation of these names to addresses, possible by going to the discovery primitives, must also be investigated.

- **Design and implement a flexible discovery system.** Within an ecosystem, many sensor nodes can exist. One cannot expect from application developers to know these individual sensor nodes. Therefore, flexible discovery mechanisms are needed to find out the available sensor nodes in the network, augmented with filtering mechanisms and integrated with the naming system, so to only find the nodes of interest. With such a system, discovering nodes within the ecosystem must be as least as simple as discovering services in today’s LAN network using mechanisms such as Bonjour.

- **Design and implement an application developer API.** In order to make the ecosystem fully usable, it should be possible to implement applications on top of it. Since we do not want that applications developers have to deal with address, sockets, ports… we will design a flexible API to address sensor and to retrieve data. For example using calls such as
“temperature.home,10” should be sufficient to retrieve the temperature of all temperature sensor nodes at home every 10 minutes. Behind such a powerful API, an engine is needed that translates the calls and directs them to the naming, discovery and transport mechanisms.

Once more, the measurable output of these objectives will be a set of software building blocks. During design time and initial development time, this output will come in the form of reports describing the design specifications. For these 3 objectives, the following 7 milestones help verifying their achievement: milestone 4.3 (month 7) provides a draft specification of naming and discovery solutions, followed by joint milestones 4.4 and 5.2 (month 9) that deliver the specification of the API. Milestone 4.5 (month 14) delivers a first version of the implementation of naming and discovery solutions, resulting in an enhanced version at milestone 4.9 (month 18). For the API, milestone 4.7 (month 16) gives a first release of the implemented API, followed by an enhanced version at joint milestones 4.10 and 5.5 (month 20). Finally milestone 4.11 (month 24) delivers the final version of all these components ready for integration in the demonstrator.

It is important to note that for these clean-slate solutions a well-chosen set of novel clean-slate end-to-end protocols operating at the local scale of the virtual network will be designed that is minimally needed to demonstrate the concept for a specific application scenario. As such, only the basis functionality needed to demonstrate the concept and demonstrate an application scenario will be implemented, keeping the objectives focused and achievable.

**Development of cloud computing services and sensor services**

As already stated, cloud resources will be integrated in the MENO ecosystem. As such, the ecosystem will be able to make use of cloud services, while at the same time ecosystem services can be exported as a cloud service. These cloud services will need to interact with the clean slate protocols and API for utilizing the network features of the ecosystem. As such, the cloud resources can retrieve, store and process sensor data according to the needs of the ecosystem users, provide functionality to enrich it with data from external services, to act upon events and to expose part of the data in a controlled way to the outside world.

Next to this, a number of sensor services will be designed in order to demonstrate the clean-slate end-to-end protocols and the developed application developer API for the design of applications. These services will also make use of the access to the cloud. By enabling functionality such as aggregation, logging, storage… the creation of processing chains to easily collect and manage sensor data will be made possible.

To this end, the following objectives will be realized:

- **Develop cloud access functionality from within the ecosystem** for making cloud services available to the ecosystem and offering an API to benefit from cloud functionality such as: means to store and process sensor data, to enrich the data... To do so, the newly developed API and clean-slate protocols will be used. When needed, the cloud resources will scale according to the required processing or storage capabilities.

- **Allow the enrichment of the collected sensor data**, with data coming from external services.

- **Offer a cloud service to expose the data collected from within the ecosystem**, possibly after being enriched, in a controlled way to interested parties outside the ecosystem.

- Development of a **selected set of sensor services** that use the new API and the ability to use cloud services, to offer generic functionality such as aggregation, logging, event triggering...

The same principle for verification is used here, resulting in 4 milestones that can be used to measure the progress of the design specification and development. **Milestone 5.1 (month 8)** delivers the draft specification of the cloud and sensor services based on application scenarios. This specification is extended based on the designed clean-slate protocols and application developer API, resulting in **milestone 5.3 (month 13)**. **Milestone 5.4 (month 18)** releases a first version of the implementation of these services, followed by an enhanced version at **milestone 5.7 (month 24)** that is ready to be integrated in the final demonstrator.
Validation and demonstration

By safeguarding the interfaces and API’s between the different components during the design, it is MENO’s objective to **integrate the different components and showcase the feasibility of the concept and the good functioning of the designed solutions for a specific application scenario**. This process will consist of the creation of both an integration and test plan, the presentation of test reports and the release of a first integrated demonstrator. The integration plan is released at **milestone 5.6 (month 22)**, followed by the release of the test plan at **milestone 5.8 (month 24)**. **Milestone 5.9 (month 26)** presents the test results of the conformance verification and interoperability tests. The first integrated prototype is delivered in **month 28**, resulting in **milestone 5.10**.

S&T objectives verification and measurement

As already stated, almost all objectives specified in this section will be reached through a two-stage process consisting of design and implementation. The design specifications will produce a number of documents, whereas the implementation work will result in software modules and building blocks to be integrated. These building blocks must implement the functionality of the corresponding objective. At the end, everything will come together into one integrated demonstrator showcasing a selected application scenario, the ultimate tangible output of this project. Since the main goal of this project is to demonstrate and showcase the **feasibility** of novel end-to-end solutions for accessing sensor nodes, measurement can almost solely be done in terms of the generation of specification documents, coding effort, delivery of software components that fulfil the required functionality and the realization of a demonstrator implementing an application scenario using sensor and cloud services, opposed to pure performance and efficiency measurements and metrics.

In the above paragraphs, most milestones that can be used for verification of the design and implementation have been mentioned explicitly. Next to this, one set of milestones will deal with the overall specification of the end-to-end system according to the requirements of a well-chosen set of application scenarios and will serve as a guide for the overall design. This will produce a number of incremental reports describing the overall end-to-end system and the application scenarios targeted by this system. **Milestone 2.1 (month 2)** reports on relevant ecosystem scenarios, whereas **milestone 2.2 (month 2)** describes the initial blueprint of the system, consisting of the major components. The requirements derived from the scenarios result in **milestone 2.3 (month 4)**. **Next, milestone 2.4 (month 6)** delivers the enhanced blueprint, taking into account these requirements. Later on in the project, **milestones 2.5 (month 17) and 2.7 (month 25)** will provide a refined architecture taking into accounts the research that has been carried out. Finally, **milestone 2.6 (month 22)** drafts the scenario that will be demonstrated.

Together, all these milestones form a red line throughout the project that allows monitoring the overall progress in a measurable and verifiable form and as such, the achievement of the objectives.

1.1.3 Relation of Objectives to Call Topics

MENO addresses ICT Challenge 1 – Pervasive and Trustworthy Network and Service Infrastructures, **Objective ICT-2009.1.1: The Network of the Future** and fits the target outcome **Future Internet Architectures and Network Technologies**. The following table explains how the project’s objectives related to this target outcome.

<table>
<thead>
<tr>
<th>Objective ICT-2009.1.1 a) Future Internet and Network Technologies</th>
<th>Relation with MENO objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overcoming structural limitations of the current Internet architecture arising from an increasingly larger set of applications and devices</td>
<td>The Internet architecture has been designed in order to interconnect computers over wired connections. With the advent of wireless devices and restricted devices such as sensor nodes, structural limitations of the design come up. Sensors can only be added as an add-on, IP protocols are not designed for and too heavy for sensor nodes, secure collaboration between heterogeneous, distributed and mobile devices is difficult to</td>
</tr>
</tbody>
</table>
achieve... At the same time, the advent of sensors enables many new applications, for example in the machine-to-machine domain, that impose different requirements. MENO’s objectives aim to overcome these limitations through the design of an end-to-end system that combines network virtualization and novel end-to-end protocols. The design takes into account the limitations imposed by the most restricted devices and offers solutions tailored to the requirements of novel applications.

| Novel Internet architectures and technologies enabling dynamic, efficient and scalable support of applications with various traffic patterns... point-to-point or point-to-multipoint distribution modes | It is MENO’s objective to implement a set of novel clean-slate end-to-end protocols. As underlying technology, network virtualization is being used, but extended to sensor nodes. As such, a novel architecture is designed that allows flexible and efficient communication with sensor nodes, hereby taking into account the various traffic patterns being encountered such as point-to-point and point-to-multipoint. The objectives take these distribution modes in account from the very beginning of the design. |
| The target architecture should support ... machine-to-machine communication, wireless sensor networks, ad-hoc connectivity networks... | The MENO system targets flexible and secure end-to-end communication with sensor nodes and will provide natural support for this type of communication. The design of end-to-end protocols and the integration of cloud resources will enable many scenarios, many of them related to machine-to-machine communication. |
| It should... natively support mobility... Routing and location-independent addressing or naming... and end-to-end content delivery techniques are related research issues. | The end-to-end protocols run on top of a virtual network, where the virtual network transparently maintains the connectivity between the objects in the network and as such provides native mobility support. Within the virtual environment, a clean slate design supporting routing, addressing, naming and efficient distribution of sensor data is targeted. |
| Migration paths and coexistence through overlay, federation, virtualisation and other techniques... | The MENO project takes a clean slate approach for the design of end-to-end protocols for communication between sensor nodes and other more powerful network devices. By developing these solutions on top of a virtual network, the developed solutions can be deployed immediately on top of the existing Internet. As such, our approach offers a migration path through virtualisation. |
| Clean slate or evolutionary approaches, or a mix of these, can be equally considered. | As said, a clean slate approach is taken for the design of end-to-end protocols for communication between sensor nodes and other more powerful network devices, but this clean slate approach is restricted to a virtual network environment, comprising the involved end devices, in which it will be deployed. The combination of both can be seen as an evolutionary approach. In a first phase (which is the objective of the project), immediate deployment of the developed solutions on top of the existing Internet is possible through virtualization. Later, this virtualization technology could become part of the Future Internet design, and the developed end-to-end solutions could be deployed directly on top of the Future Internet’s network layer. |
1.2 Progress beyond the state-of-the-art

This section will provide in a structured way an overview of the state-of-the-art and will describe the advancements the proposed project will bring or how the project will optimally make use of the available state-of-the-art as a baseline to build upon and to reach it’s objectives.

1.2.1 Today’s communication between sensor nodes and IP devices

Traditionally, sensor networks were not IP-enabled. Hence, when these sensor networks were integrated into IP-based infrastructures, gateways or proxies were deployed at the boundaries of these domains. These gateways act as protocol-translators between the non-IP communication protocols in the sensor network and the IP communication in the Internet and work at application level [Zuniga03]. However, the use of protocol translation gateways breaks the end-to-end communication paradigm and has proven to be inherently complex to design, manage and deploy [IPSO-1][Mayer06]. Furthermore, when a new sensor protocol is developed, a new gateway needs to be implemented. Therefore, and in order to increase interoperability between sensor nodes from different vendors, a trend has emerged to access these networks with IP.

In [Zuniga03], it is stated that an all IP sensor network is not feasible, mainly because of the fact that the sensor nodes are resource-constraint. They suggest introducing heterogeneity in the network by assigning IP addresses to a limited number of devices, thus creating an IP-overlay network. This solution requires that these IP-sensor nodes have more resources and it requires a gateway to connect to the network. However, this proposal was not implemented nor properly evaluated.

A first attempt to implement an IP stack on sensor nodes is uIP [uIP], an open source TCP/IP stack capable of being used with tiny 8 and 16 bits microcontrollers. uIP has evolved to include a low-power link built on IEEE 802.15.4, showing that a reduced version of IP was feasible for WSNs. uIP does not offer multicast functionality, a functionality that is very important looking at the data flows in sensor networks.

Based on the success of uIP, a working group was created by the IETF: 6LoWPAN [RFC4944]. This standard describes an adaptation layer between IPv6 and IEEE 802.15.4. IPv6 header compression is used to enable efficient communication. This solution still uses a gateway for connection between the sensor network and the IP network, but by standardizing the protocols, the translation is much simpler and can be done at network level, without entirely loosing the end-to-end concept. This standard is supported by the IPSO alliance, which is about using IP (IPv4 or IPv6) for interconnecting smart objects [IPSO-4]. The NanoStack developed by SensiNode uses concepts of this standard.

The design of a complete IPv6-based network architecture for wireless sensor networks is given in [Hui08]. To connect a sensor network with other IP networks, border routers are used. These mainly forward IP datagrams at the network layer, without the need to maintain any application-layer state. A similar approach is used in IPSA [Chen09].

It is clear that all these solutions take the same design approach: look how the IP world works and bring it to the sensor world by stripping of functionality and introducing gateway translations where needed. We claim that this is not the most optimal solution, since this approach starts from solutions developed with the requirements of the most powerful devices in mind and these do not at all fit those imposed by sensor nodes. It offers a workable short-term solution, but in the longer term a novel design is needed. The MENO project progresses beyond this state-of-the-art by taking a new design approach, starting from the most limited devices, i.e. the sensor nodes and designing solutions tailored to the characteristics of these nodes, and at the same time operating in an end-to-end fashion.

The previous solutions were mainly dealing with bringing the IP network connectivity to the sensor world. Next to this, many initiatives exist that want to offer complete sensor network integration frameworks. A very good summary of these frameworks is given in [SENSEI-D1.3] and will not be repeated here. There are frameworks that want to provide access to sensor data by collecting the data into a database (IrisNet and JWebDust), by establishing a data collection network (Hourglass) or by creating a centralized broker (Janus), which can be consulted by applications to discover or access.
sensor data. Some of them even look at the integration with IMS (e-Sense and Ubiquitous Sensor Networks). Other initiatives such as Sensor Web Enablement (SWE) and SenseWeb focus on web applications and present solutions for making sensor networks accessible and controllable by web-based applications. Interesting to mention here is that SWE has developed SensorML [SensorML], a sensor model language that can be used to describe sensors and measurement processes. Similar functionality will be needed in the discovery and naming solutions the MENO project proposes and as such, the project will certainly take this approach into account.

Looking at all these frameworks, we can observe that they make use of centralized brokers that are connected with gateways or proxies at the border in the different sensor networks, that they make use of a n-tiered architecture, that they introduce intermediate brokers or agents or that they continue to make use of the dedicated sensor gateways or sinks. In all cases, there are one or multiple levels of indirection in order to get the sensor data. The MENO project advances this existing state-of-the-art by really looking into complete end-to-end solutions, directly between the sensor nodes and the more powerful devices.

The SENSEI project [SENSEI] aims to solve the limitations (e.g. security, management...) of the above mentioned frameworks and wants to integrate heterogeneous wireless sensor and actuator networks (WS&AN) into a common framework of global scale and to make the services and applications available via universal service interfaces. The SENSEI solution provides necessary network and information management services to enable reliable and accurate context information retrieval and interaction with the physical environment. They focus on how these interconnections between WS&AN islands are made and how the services can be discovered and shared. Internally in these WS&AN islands, the SENSEI project aims to design efficient energy-aware protocol stacks. In order to communicate with these islands, a gateway is still used to establish the interconnection between the sensor world and the Internet world.

Also, the framework the SENSEI project aims to develop is a global scale framework, aiming to bring the sensor world to the rest of the Internet and let applications access a large variety of connected geographically distributed sensor networks. In that respect, the MENO project is different. Its purpose is not to make sensor data accessible to the whole world, but to group all the involved actors in the targeted application scenarios and to optimize sensor communication within these closed groups through the design of novel end-to-end protocols. It wants to provide an efficient integrated end-to-end system for the targeted application scenarios, instead of a global solution to make sensor data accessible to the whole world. This is also reflected in the MENO design approach: using network virtualization to securely and automatically group the involved devices and design solutions within the scope of this virtual network. In that respect, the MENO approach is unique, has not been addressed by any other project and definitely will progress beyond the current state-of-the-art.

Next to this, there a few other EU projects in this area that is worth mentioning.

The ITEA2 UseNet (Ubiquitous M2M Service Networks) project [USENET] is developing universally applicable service concepts based on M2M communications. A number of MENO partners is active in this project. Within this project, network virtualization is being used as a means to create a virtual IP network (see also section 1.2.2) that interconnects back ends and sensor gateways. Access to the sensor data from within this IP network is taking place via these gateways that need to translate all communication. The MENO project should be seen as a highly advanced extension of concepts deployed by MENO partners in this project. It advances their work in this project in many ways such as the inclusion of sensor nodes in the virtual network, the design of novel clean-slate end-to-end protocols... and as such requires extensive research.

The SensorGrid4Env project [SENSORGGRID] aims to specify, design, implement, evaluate and deploy a service-oriented architecture and middleware, which allows application developers to build open large-scale semantic-based sensor network grids for environmental management. The project focuses on the semantic middleware layer and API (with focus on web applications and mashups using the REST API), operating on the sensor data that is retrieved in a “traditional” way, via gateways to the sensor networks. The MENO project will also look at an API for application developers, but this API will give access to the newly developed clean-slate end-to-end protocols. Also, the target
applications are different, since focus is on cloud services that will process the sensor data in several
different ways.

1.2.2 Network virtualization and the integration of sensor nodes

Network virtualization can be viewed in two ways [NetVir]. Firstly, one can view it as a tool for
evaluating new disruptive architectures on a large scale as part of the design of the Future Internet.
Secondly, one can view it as a fundamental diversifying attribute of the next-generation architecture
itself, where multiple virtual networks can coexist, as is being done in the FP7 4WARD project
[4WARD]. This is also the viewpoint of [NetVir2], where the authors state that network virtualization
should lay the foundation for the coexistence of diverse network designs and paradigms. This
viewpoint is the one taken by this project, i.e. ecosystems as part of the Future Internet that has built-
in network virtualization. Since network virtualization as part of the Future Internet is ongoing research
and since this project wants to demonstrate ecosystems over the current Internet, we need to foresee
our own network virtualization solution. As such, this section will focus on network virtualization
solutions that can serve as a basis for realizing the virtual networks we envision over today’s
Internet: including sensor nodes, capable of running on top of real hardware, running both over L3
and different L2 connections, and on top of which our clean-slate solutions can be deployed without
any limitations.

The concept of multiple co-existing logical networks (also called virtual networks, overlay networks)
appears in literature several times in the past and in many different forms. For example, virtual LANs
are the logical grouping of a subset of devices belonging to an Ethernet system [VLAN], but are limited
to a single networking technology, whereas we want to cross multiple heterogeneous technologies.
Virtual Private Networks [VPN] are private data networks that make use of the public
telecommunication infrastructure, thereby maintaining privacy through the use of a tunneling protocol
and security procedures. This solution requires that all involved nodes have Internet connectivity, is
mostly centrally managed, is IP-based and thus rules out sensor nodes or L2 connections on top of
which the virtual network can run. In P2P application level overlays [P2P], applications running on
distributed systems create logical links between each other using native Internet routing and standard
IP addresses. Again, these solutions require Internet connectivity, rule out L2 and are located at a way
too high in the networking stack to be taken into consideration for the extension towards sensor
nodes. Next, to these there are some other different virtualization projects. VNET [VNET]
interconnects virtual machines with existing remote networks as if they were connected over layer 2,
offering a L2 virtualization layer on top of which IP networking between the virtual machines and the
remote IP-based networks can take place. Again, focus is on IP networking and the virtualization layer
is L2 and thus not technology agnostic, a requirement we have in order to create a virtual network
over different technologies (L2 and L3) on top of which completely new protocols can be designed.
VIOLIN [VIOLIN] proposes isolated application-level virtual networks for virtual machine
communications, created on top of an overlay infrastructure that runs on top of the Internet. Again, this
is completely IP based and its focus on virtual machines and grid computing rules out the extension
towards sensor nodes. Similarly, the FP6 IST AGAVE project [AGAVE], used network virtualization on
top of IP, in order to create “Parallel Internets” tailored to service requirements. Another example is X-
Bone [XBONE], which dynamically deploys and manages Internet overlays over existing IP networks.
Although its management functionality has some interesting characteristics that could be looked at, it
has the same limitations when viewed with respect to our requirements. It is clear that none of the
solutions discussed so far, provide an easy migration path towards the network virtualization
solution that is needed in this project.

The best baseline to start from is offered by the experience on and implementation of virtual networks
by several project partners, through their participation in the FP6 IST projects MAGNET [MAGNET]
and MAGNET Beyond [MAGNETBEYOND] on Personal Networks. In these projects, they have
designed and deployed virtual IP networks of IP-capable devices, running both on top of layer 2 and
the IP-based Internet [PN] as shown in the following figure.
Here, IP-capable devices that need to securely communicate with each other for achieving a common goal form a virtual IP network in which they can securely and transparently communicate. The virtual links of this network are either created on top of L2 (when there is a direct link between two devices) or on top of L3 (when the devices are distributed and connected to the Internet). On top, an IP network with its own private addressing space has been created, in which any existing or new IP application can run. This work has been further generalized through the concept of Virtual Private Ad Hoc Networks [VPAN], allowing the coexistence of multiple parallel virtual networks. The interesting aspects here are the following: first of all, only devices that trust each other and that need to cooperate are included in the virtual network, which fits the idea behind our ecosystems. Next, solutions to establish a virtual network, not only on top of L3 (the Internet), but also on top of L2 have been developed, providing a good basis to extend this to sensor nodes. At the same time, this approach also easily allows the integration of virtual machines, on which cloud computing heavily relies, into the virtual network. On the other hand, there are several limitations in order to be usable to realize the proposed ecosystems. The most important are: sensor nodes with limited capabilities (no IP) and their specific characteristics are not considered. The convergence layer is IP-based, which assumes that all devices speak IP and thus not allowing a clean-slate design. However, from all existing virtualization solutions, it offers the best foundation to start from in order to realize the virtualization layer of our ecosystem within the time frame of the project, and as such it has been clearly described in our objectives what is needed to overcome these limitations.

It is clear that none of the discussed network virtualization solutions include sensor nodes, a point where this project will go beyond today's state-of-the-art. Of course, adding sensor nodes to a virtual network will pose new challenges that will impact the design. Most importantly, since only trusted nodes may become part of the ecosystem, one should be able to install a trust relationship also on sensor nodes and execute the resulting security algorithms on these nodes to guarantee confidentiality, integrity and data freshness. This is challenging, since sensor nodes have limited storage, computation, power resources and mostly operate wirelessly over a short range. For example, the processing speed of the micro controllers in sensor nodes often does not allow advanced security mechanisms, whereas these will be used in other parts of the ecosystem. Since storage and memory are limited, the code size of the security algorithms must be limited or reduced. It is clear that a lightweight solution that offers a high enough security level is required for sensor nodes to securely join the ecosystem. Concerning public key cryptography techniques in sensor networks, these were considered to be too computational, but in [Malan04] it has been shown that it is feasible with the right selection of algorithms, namely elliptic curve cryptography [ECC], since it requires smaller key lengths for a given level of security than for example RSA public key cryptography and is thus more suited for sensor nodes. This is also confirmed in [Amin08] and demonstrated by [Uhsadel07]. Also the impact of this type of cryptography on the lifetime of the sensor has been studied [Piotrowski06][Amin08]. The alternative is symmetric encryption such as 3DES or AES, which is often supported by the sensor hardware itself and which is based on a shared key, leading to the problem of the distribution and renewing of these keys. To solve this key management problem, several solutions have been proposed based on random pre-distribution schemes, such as [Liu05].
Based on multiple keying mechanisms such as the LEAP protocol [Zhu03] or based on the common trust with a third node as in the PIKE system [Chan05], but in general it is assumed that public key cryptography solutions facilitate much simpler security protocols, mainly because of its benefits for key distribution.

In this respect the AWISSENET (Ad-hoc personal area network & Wireless Sensor SECure NETwork) project could be interesting [AWISSENET]. This project focuses on security and resilience across ad-hoc PANs and wireless sensor networks. AWISSENET motivation is to implement and validate a scalable, secure, trusted networking protocol stack, able to offer self-configuration and secure roaming of data and services over multiple administrative domains and across insecure infrastructures of heterogeneous ad-hoc & wireless tiny sensory networks. The scope of this project is clearly different from the MENO project, but the security solutions designed their could be interesting to look at in view of the inclusion of sensor nodes in the virtual network.

We go beyond this state-of-the-art by applying existing security solutions for the purpose of adding selectively sensor nodes to a virtual network by installing a trust relationship using public key cryptography and using this trust relationship to further secure the virtual links these nodes establish and thus the end-to-end protocols running on top. To our knowledge, security on sensor nodes has never been applied in this way and requires going beyond the current state-of-the-art on how security is traditionally applied in sensor nodes. For example, in the (most occurring) case where a sensor node will not be able to directly connect to the Internet, but is capable of doing so via a directly connected powerful trusted node, our solution to establish a secure virtual link over L2 needs to be redesigned to match the capabilities of the sensor node concerning cryptography. When not connected directly, a secure connection between the sensor node and the more powerful node needs to be established over part of the sensor network, posing new challenges not tackled today. In some cases, when the sensor node capabilities allow (for example, sensor nodes capable of running 6LoWPan), it could be possible to implement minimal IP functionality, for example based on tinyIP [TinyIP], connect directly to the Internet and to talk securely with a dedicated anchor point of the ecosystem. All depends on the topology and capabilities of the sensor node and will be studied in this project and goes beyond what has been done so far in this field.

1.2.3 Cloud computing

In cloud computing, dynamically scalable and typically virtualized resources are provided as a service over the Internet. Users need not be aware of the underlying technology infrastructure in the “cloud”.

Today, cloud computing comes [Vaqu09], [Dika09] in the three main flavours Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS). They provide the promises of cloud computing on different levels of abstractions, namely on virtualized infrastructures, on platforms services, or on the level of concrete applications [Reservoir][OpenCirrus][IBM][Nebula]. But today’s approaches do not offer solutions in which services realized with the cloud computing approach can utilize network services to discover and use sensor or other real-world resources. Today this always needs either active user agents or additional gateways. Both introduce additional complexity into the networks, and for each new cloud service additional (most of the time manual) configuration steps are required. This contradicts the cloud computing idea: automatic dynamic scaling of cloud services as well as no knowledge required about the network or service infrastructure.

Going beyond the state-of-the-art, MENO will enable to embed Cloud services into the MENO ecosystem. This requires changes on the Cloud side, mainly to automatically connect to the ecosystem and to provide the connection in such a way that it automatically scales with the amount of resources needed. Furthermore, we aim at providing sensor-data based services out of the ecosystem to the Cloud. This also requires examining how the ecosystem can scale to the task.

1.2.4 Development frameworks

Since, it is our objective to implement the proposed concepts and demonstrate them on real hardware, we would benefit from a very flexible development framework that is suited for networking and protocol design. Since the hardware requirements of the standard IP devices such as PCs and laptops are very different than those of sensor nodes, both a development framework for
sensor nodes and more powerful devices needs to be selected. Such a framework should be modular, allowing the easy addition of new building blocks and at the same time allowing parallel development. This greatly reduces development time and stimulates cooperation between partners.

For standard IP devices such as laptops and PCs, several development frameworks exist. However, since we will use our previous work on network virtualization as a starting point to build the virtual network layer and the novel convergence layer of the ecosystem, it is a natural choice to reuse the same framework for this purpose. The framework used in [VPAN] and partly in [PN] is Click Router [CLICK]. Click Router is a software architecture for building flexible and configurable routers, but can be used for implementing any network level packet processing functionality, which is required to create virtual networks. It has a large user base, a very active developers' mailing list and runs on almost any Linux platform. For the implementation of the trust relationship and security of the virtual links the widely used OpenSSL library has been used [OpenSSL]. For the clean-slate end-to-end design on these standard devices, it is no requirement to use Click Router. It could be useful for the design for the implementation of the clean-slate networking functionality, but other frameworks could be used for the discovery and naming, as long as the interfaces are carefully designed.

For the extension of the virtual network to sensor nodes, we have already stated that cryptography forms an indispensable component. In this area some libraries are freely available that offer cryptography functionality for sensor nodes. TinyECC [Liu08][TinyECC] is a configurable library that provides elliptic curve cryptography functionality for sensor nodes running TinyOS. TinyKeyMan [TinyKeyMan] provides a TinyOS implementation for pairwise key establishment in sensor networks and TinySec [TinySec] is a link layer encryption mechanism which is meant to be the first part in a suite of security solutions for tiny devices running TinyOS.

Next to this, a general development framework that allows the easy implementation of novel protocols on sensor nodes would be of great value. Such development frameworks for wireless sensor network focus on adaptive and easy-to-configure middleware layers [Heinzelman04]. These middleware efforts typically differ from those for IP devices by having a small memory footprint, focusing on energy-efficiency and supporting location-awareness. Sentire [Branch2005] is a well known example that partitions the middleware in logically related components, which can be used by different developers to create a common plug-in infrastructure. Other middleware layers, such as Cougar [Yao2002], provide a distributed database interface to the information from a sensor network with database-style queries. Power is managed by distributing the query among the sensor nodes to minimize the energy consumed to collect the data and calculate the query result.

To support network connectivity, middleware layers depend on underlying networking provisions. Frameworks such as SNA [Tav2007] provide a modular network layer. The individual modules can be combined by the protocol designers to "build" a custom network protocol. The information driven framework IDRA developed by IBBT [IDRA] is very promising for heterogeneous ecosystems. By decoupling the protocol logic and the packet structure, modules can access the information of any network module. It includes cross-module information exchange repositories, system-wide QoS control and an adaptive protocol selector that selects the most optimal network modules based on the network context.

As such, the project is well aware of existing development frameworks and will consider them as a baseline to start from and will extend their functionality in order to achieve the project's objectives.

1.2.5 Relevant Future Internet activities and projects

Within Europe and around the world, many activities related to the Future Internet are taking place. For example, the following is a brief overview of some European projects related to Future Internet and their scope:

- 4WARD [4WARD]: builds new network architectures for Future Internet based on radical design approaches
- ECODE [ECODE]: develops a cognitive routing system
- RESUMENET [RESUMENET]: will embed resilience into the Future Internet
- Perimeter [PERIMETER]: will establish a user-centric paradigm for seamless mobility in Future Internet
- MOMENT [MOMENT]: will investigate monitoring and management in future network infrastructures
While we are focusing in this project on a clean slate design within a small-scale (compared to the whole Internet) virtual environment including sensor nodes, it is clear from their scope that many of these projects are aimed at redesigning or improving core functionality of the Internet itself and do not really take into account sensor nodes as a fundamental part of the design. As such, their focus is very different and this project goes beyond what is currently being done. On the other hand, ongoing activities do not necessarily contradict with our approach, since network virtualization, on top of which we build, is often seen as part of the Future Internet design. One of the main differences here, is that our network virtualization solution is located solely in the end devices that are part of the virtual network, since we want to be able to deploy it on top of today's Internet, whereas research activities that investigate network virtualization as a component of the Future Internet, will build this into the core of the Internet. In the following sections, we will motivate this viewpoint by discussing only the projects that are directly relevant to this proposal.

The FP7 4WARD project [4WARD] builds new network architectures for Future Internet based on radical design approaches. Their aim is to design inter-operable and complementary families of network architectures. This will be realized by incorporating the coexistence of virtual networks as a fundamental part of the design [4WARD2]. This is in line with our project's goal, where we also envision virtualization as part of the Future Internet. However, as already stated, since a working virtualization solution is needed for development and testing on real hardware, we will foresee our own virtualization layer by implementing it in the end devices, which in the future could be replaced by the network virtualization functionality of the Future Internet, which is expected to be developed in a systematic and general approach, but will take a longer time frame to be fully operational. Next to this, the project also proposes some radical design approaches such as in-network management, generic connectivity and content-centric network of information [4WARD3]. The latter approach will create a new information-centric paradigm where information objects have their own identity, which would revolutionize application support. Although very interesting, the focus is on the Future Internet as a whole and is not focused on lightweight objects with limited capabilities such as sensor nodes or applications thereof. Nevertheless, the project claims that their solutions will embrace the full range of current and future technologies, including sensor networks, but we believe that due to the restrictions sensor nodes impose, a focused clean-slate design is needed, since no single solution will fit everything. Therefore, since sensor nodes will become an integral part of the Future Internet, our proposed clean-slate design on top of the virtualization, which is also envisioned by the 4WARD project, represents another valuable and complementary step towards the Future Internet design.

The FP7 OPNEX project [OPNEX] will design architectures and protocols for multi-hop wireless networks. They will rethink the wireless network protocol stack by incorporating control and optimization theory principles and will build lightweight implementations of existing protocols. Since ecosystems are essentially multi-hop networks (as seen on top of the virtualization layer), the project could benefit from some of the results obtained in this project. Further, the project also aims to build an experimental sensor network test-bed, so sensor nodes are taken into consideration. On the other hand, the MENO project does not look at the wireless multi-hop part in isolation, but wants to develop clean-slate end-to-end solutions up to the developers’ API and is in this respect quite different. Nevertheless, the results of this project should be followed closely.

1.2.6 Demonstration

It is the goal of the project to integrate the different components and showcase the feasibility of the concept and the good functioning of the designed solutions. In order to evaluate and validate these novel solutions, it is a prerequisite to be able to deploy them on real hardware and within a heterogeneous communication environment, including at least both sensor nodes and standard PCs. Currently, many facilities make a separation between both. Also, the sensor node hardware must match the chosen development framework(s) for sensor nodes. To this end, the project will make use of existing test bed facilities. In that respect, some of the project’s partners are involved in the European experimental facilities initiatives, both including standard machines and sensor nodes. For
example, Panlab – PII [PANLAB] addresses the need for large-scale testing facilities in the communications area. It offers a test bed repository, where an overview of available test beds can be found with a detailed technical description. Many test beds are available, including a wide range of different technologies (sensor nodes, Wi-Fi, IMS, Ethernet...). Some of the partners of the MENO project also make some of their test beds available through this initiative such as iLab.t Virtual Wall, iLab.t Wilab [iLAB]... **The project will make use of these facilities to reach it’s objective of building a demonstrator of the design solution.**

### 1.2.7 Overall conclusion

The integration of sensor node and cloud resources in a virtual network environment and the design of a complete set of end-to-end solutions goes way beyond the current state-of-the-art. The project will bring advances in several areas, the most important being:

- Integration of sensor nodes into a secure virtual network
- Real end-to-end protocols for communication between sensor nodes and other network devices, made available via a flexible API to application developers
- Demonstrate flexible sensor data management through cloud services
- Demonstration of the designed solutions on real hardware for a relevant application scenario

In addition, the project has a clear view on available development frameworks, state-of-the-art that can serve as a baseline for the work carried out in the project and available test beds, forming a solid basis for achieving its objectives.
1.3 S/T methodology and associated work plan

1.3.1 Work plan

To achieve its goals, the project has been decomposed into 4 technical work packages and clearly defined subtasks, closely related to the different objectives and their inter-relationships. As such, it closely follows the logical phases partners have to go through in order to achieve the final goal of the project. A separate work package deals with project management and coordinates the overall progress of the project. An additional work package targets the dissemination and exploitation of the project results. This leads to the following six work packages:

- **WP1: Project management** - WP1 will deal with the overall project management, including monitoring and safeguarding the work progress and completion of the EU requirements. In this WP, the coordinator will also follow up all legal, contractual, financial and administrative management. A particular care will be brought to the quality of the works and to the respect for deadlines.

- **WP2: Scenarios, requirements and architecture** - WP2 will develop a number of scenarios that are targeted by the end system and will look at the requirements they will impose on the end-to-end system. The work package also represents the core of the overall end-to-end system design, responsible for defining the general blueprint of the system that will guide the other work packages.

- **WP3: Ecosystem creation and management** - WP3 will handle the creation of the ecosystem, including the addition of sensor nodes and cloud resources to the ecosystem through the establishment of a trust relationship and the subsequent management of the ecosystem. Next to this, it will take our existing virtual network solutions as a baseline and will extend them to sensor nodes. Finally, in a cross-task with WP4, the virtual adapter will be designed and implemented, where WP4 will deliver the requirements and WP3 is in charge of implementing the adapter according to these requirements.

- **WP4: Clean-slate end-to-end protocol design** - WP4 will deliver their requirements on the virtual adapter design to WP3 in a cross-task. Next to this, WP4 will use this design as a foundation for the development of the clean-slate end-to-end protocols. It will develop the addressing, unicast and multicast solutions and sensor discovery and naming solution that are needed to support the identified scenarios and to meet their requirements. WP4 is also responsible for the design of the API for the application developers that will make use of the new protocols. This is again done in a cross-task, where WP5 will deliver the requirements on this API in order to implement the ecosystem services and WP4 will design and implement according to these requirements.

- **WP5: Ecosystem services and demonstration** - WP5 will deliver the requirements on the API to WP4 in a cross-task. Next to this, WP5 is responsible for the design of the cloud and sensor services. These cloud and sensor services will make use of this API and will enable the sensor data processing, enrichment and management. Since, these services span the whole end-to-end system and they will form the basis for the demonstration of a specific application scenario (delivered by WP2), this WP will also take care of the integration of an end-to-end demonstrator (using components from WP3 and WP4 and the developed cloud services and verifying the requirements from WP2) that will demonstrate the feasibility and good functioning of the designed solutions.

- **WP6: Project dissemination and exploitation** - WP6 will take care of all activities related to the dissemination and exploitation of knowledge generated within the project. Scientific and industrial dissemination will take place through publications, conferences, workshops, white papers, etc. targeting a broad audience of interested parties (both research and industry). Also, possible exploitation plans will be defined and the results will be used to contribute to standardization bodies.

It is clear that this WP structure closely follows the objectives of the project. Since an end-to-end system is being built and different components are closely interrelated with each other, 2 cross-tasks have been foreseen. These tasks enforce the close cooperation of partners working on different parts of the design, but using a common interface, whereas WP2 safeguards the overall design. Together with the logical WP breakdown, this work plan will contribute strongly to the achievement of the objectives.
1.3.2 Project planning

The presented work plan closely follows the logical phases partners have to go through in order to achieve the final goal of the project. Since an end-to-end system is being built, many components rely on each other. This is partially ensured by the introduction of cross-tasks. On top of this, a good timing of the different work packages and their tasks is needed, as presented in the following project planning.

<table>
<thead>
<tr>
<th>WP1</th>
<th>Project management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task 1.1 - Project Organization and Management</td>
<td></td>
</tr>
<tr>
<td>Task 1.2 - Project Quality Management</td>
<td></td>
</tr>
<tr>
<td>WP2</td>
<td>Scenarios, requirements and architecture</td>
</tr>
<tr>
<td>Task 2.1 - Scenarios and derivation of requirements</td>
<td></td>
</tr>
<tr>
<td>Task 2.2 - End-to-end system blueprint</td>
<td></td>
</tr>
<tr>
<td>WP3</td>
<td>Ecosystem creation and management</td>
</tr>
<tr>
<td>Task 3.1 - Ecosystem participation</td>
<td></td>
</tr>
<tr>
<td>Task 3.2 - Ecosystem management</td>
<td></td>
</tr>
<tr>
<td>Task 3.3 - Virtual network creation</td>
<td></td>
</tr>
<tr>
<td>Task 3.4 - Virtual adapter design and implementation</td>
<td></td>
</tr>
<tr>
<td>WP4</td>
<td>Clean-slate end-to-end protocol design</td>
</tr>
<tr>
<td>Task 4.1 - Virtual adapter design and implementation</td>
<td></td>
</tr>
<tr>
<td>Task 4.2 - Distribution of sensor data</td>
<td></td>
</tr>
<tr>
<td>Task 4.3 - Sensor discovery and naming</td>
<td></td>
</tr>
<tr>
<td>Task 4.4 - Application developer API</td>
<td></td>
</tr>
<tr>
<td>WP5</td>
<td>Ecosystem services and demonstration</td>
</tr>
<tr>
<td>Task 5.1 - Application developer API</td>
<td></td>
</tr>
<tr>
<td>Task 5.2 - Cloud and sensor services design and implementation</td>
<td></td>
</tr>
<tr>
<td>Task 5.3 - Integration and validation of solutions</td>
<td></td>
</tr>
<tr>
<td>Task 5.4 - Demonstration of an application scenario</td>
<td></td>
</tr>
<tr>
<td>WP6</td>
<td>Project dissemination and exploitation</td>
</tr>
<tr>
<td>Task 6.1 - Scientific and industrial dissemination</td>
<td></td>
</tr>
<tr>
<td>Task 6.2 - Exploitation and contribution to standardization</td>
<td></td>
</tr>
</tbody>
</table>

Legend: Task fully active | Task less active |
1.3.3 Work description

1.3.3.1 Work package list

<table>
<thead>
<tr>
<th>Work package No</th>
<th>Work package title</th>
<th>Type of activity</th>
<th>Lead partic no.</th>
<th>Lead partic. short name</th>
<th>Person-months</th>
<th>Start month</th>
<th>End month</th>
</tr>
</thead>
<tbody>
<tr>
<td>WP1</td>
<td>Project Management</td>
<td>MGT</td>
<td>P01</td>
<td>IBBT</td>
<td>20</td>
<td>M1</td>
<td>M30</td>
</tr>
<tr>
<td>WP2</td>
<td>Scenarios, requirements and architecture</td>
<td>RTD</td>
<td>P06</td>
<td>RMoni</td>
<td>33</td>
<td>M1</td>
<td>M30</td>
</tr>
<tr>
<td>WP3</td>
<td>Ecosystem creation and management</td>
<td>RTD</td>
<td>P01</td>
<td>IBBT</td>
<td>65</td>
<td>M1</td>
<td>M30</td>
</tr>
<tr>
<td>WP4</td>
<td>Clean-slate end-to-end protocol design</td>
<td>RTD</td>
<td>P04</td>
<td>UC</td>
<td>79</td>
<td>M1</td>
<td>M30</td>
</tr>
<tr>
<td>WP5</td>
<td>Ecosystem services and demonstration</td>
<td>RTD</td>
<td>P05</td>
<td>NEC</td>
<td>64</td>
<td>M6</td>
<td>M30</td>
</tr>
<tr>
<td>WP6</td>
<td>Project dissemination and exploitation</td>
<td>RTD</td>
<td>P02</td>
<td>JCP-Consult</td>
<td>27</td>
<td>M1</td>
<td>M30</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>288</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 1.3.3.2 Deliverables list

<table>
<thead>
<tr>
<th>Del. no.</th>
<th>Deliverable name</th>
<th>WP no.</th>
<th>Nature</th>
<th>Dissemination level</th>
<th>Delivery date (proj. month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Project Reference Manual</td>
<td>1</td>
<td>R</td>
<td>CO</td>
<td>1</td>
</tr>
<tr>
<td>1.2</td>
<td>Project Quality Insurance Manual</td>
<td>1</td>
<td>R</td>
<td>CO</td>
<td>1</td>
</tr>
<tr>
<td>6.1</td>
<td>Project Web Site</td>
<td>6</td>
<td>O</td>
<td>PU</td>
<td>2</td>
</tr>
<tr>
<td>1.3</td>
<td>Knowledge Management Guide</td>
<td>1</td>
<td>R</td>
<td>CO</td>
<td>6</td>
</tr>
<tr>
<td>6.2</td>
<td>Project Communication And Dissemination Plan</td>
<td>6</td>
<td>R</td>
<td>PU</td>
<td>6</td>
</tr>
<tr>
<td>2.1</td>
<td>Ecosystem application scenarios and their requirements</td>
<td>2</td>
<td>R</td>
<td>PU</td>
<td>6</td>
</tr>
<tr>
<td>3.1</td>
<td>Specification of the virtual adapter design (jointly with WP4)</td>
<td>3</td>
<td>R</td>
<td>CO</td>
<td>8</td>
</tr>
<tr>
<td>4.1</td>
<td>Specification of the virtual adapter design (jointly with WP3)</td>
<td>4</td>
<td>R</td>
<td>CO</td>
<td>8</td>
</tr>
<tr>
<td>2.2</td>
<td>Initial end-to-end system blueprint</td>
<td>2</td>
<td>R</td>
<td>PU</td>
<td>9</td>
</tr>
<tr>
<td>3.2</td>
<td>Specification of ecosystem participation and virtual network creation solutions</td>
<td>3</td>
<td>R</td>
<td>PU</td>
<td>10</td>
</tr>
<tr>
<td>5.1</td>
<td>Initial specification of cloud and sensor services</td>
<td>5</td>
<td>R</td>
<td>CO</td>
<td>10</td>
</tr>
<tr>
<td>1.4</td>
<td>First period Progress Report</td>
<td>1</td>
<td>R</td>
<td>PU</td>
<td>12</td>
</tr>
<tr>
<td>4.2</td>
<td>Specification of clean-slate end-to-end protocols</td>
<td>4</td>
<td>R</td>
<td>PU</td>
<td>12</td>
</tr>
<tr>
<td>4.3</td>
<td>Specification of the application developer API (jointly with WP5)</td>
<td>4</td>
<td>R</td>
<td>CO</td>
<td>14</td>
</tr>
<tr>
<td>5.2</td>
<td>Specification of the application developer API (jointly with WP4)</td>
<td>5</td>
<td>R</td>
<td>CO</td>
<td>14</td>
</tr>
<tr>
<td>5.3</td>
<td>Enhanced specification of cloud and sensor services</td>
<td>5</td>
<td>R</td>
<td>PU</td>
<td>15</td>
</tr>
<tr>
<td>3.3</td>
<td>Specification of ecosystem management solutions</td>
<td>3</td>
<td>R</td>
<td>PU</td>
<td>16</td>
</tr>
<tr>
<td>6.3</td>
<td>Intermediate Dissemination Report</td>
<td>6</td>
<td>R</td>
<td>PU</td>
<td>18</td>
</tr>
<tr>
<td>1.5</td>
<td>Second period Progress Report</td>
<td>1</td>
<td>R</td>
<td>PU</td>
<td>21</td>
</tr>
<tr>
<td>2.3</td>
<td>Enhanced end-to-end system blueprint</td>
<td>2</td>
<td>R</td>
<td>PU</td>
<td>21</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
<td>Page</td>
<td>Reader</td>
<td>Case</td>
<td>Week</td>
</tr>
<tr>
<td>-----------</td>
<td>------------------------------------------------------------------------------</td>
<td>------</td>
<td>--------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>2.4</td>
<td>Demonstrator use case description</td>
<td>2</td>
<td>R</td>
<td>CO</td>
<td>24</td>
</tr>
<tr>
<td>3.4</td>
<td>Ecosystem creation and management implementation</td>
<td>3</td>
<td>R</td>
<td>PU</td>
<td>24</td>
</tr>
<tr>
<td>4.4</td>
<td>Clean-slate end-to-end protocol implementation</td>
<td>4</td>
<td>R</td>
<td>PU</td>
<td>24</td>
</tr>
<tr>
<td>5.4</td>
<td>Cloud and sensor service implementation</td>
<td>5</td>
<td>R</td>
<td>PU</td>
<td>24</td>
</tr>
<tr>
<td>5.5</td>
<td>Verification, integration and interoperability testing report</td>
<td>5</td>
<td>R</td>
<td>PU</td>
<td>28</td>
</tr>
<tr>
<td>1.6</td>
<td>Final report</td>
<td>1</td>
<td>R</td>
<td>PU</td>
<td>30</td>
</tr>
<tr>
<td>6.4</td>
<td>Final Plan for the use and dissemination of foreground</td>
<td>6</td>
<td>R</td>
<td>RE</td>
<td>30</td>
</tr>
<tr>
<td>2.5</td>
<td>Final end-to-end system and its use cases</td>
<td>2</td>
<td>R</td>
<td>PU</td>
<td>30</td>
</tr>
<tr>
<td>3.5</td>
<td>Ecosystem creation and management implementation modifications</td>
<td>3</td>
<td>R</td>
<td>CO</td>
<td>30</td>
</tr>
<tr>
<td>4.5</td>
<td>Clean-slate end-to-end protocol modifications</td>
<td>4</td>
<td>R</td>
<td>CO</td>
<td>30</td>
</tr>
<tr>
<td>5.6</td>
<td>Complete MENO end-to-end system demonstrator</td>
<td>5</td>
<td>D</td>
<td>PU</td>
<td>30</td>
</tr>
</tbody>
</table>
### Milestone list

<table>
<thead>
<tr>
<th>Milestone number</th>
<th>Milestone name</th>
<th>Work package(s) involved</th>
<th>Expected date</th>
<th>Means of verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>M2.1</td>
<td>Report describing a selection of relevant ecosystem scenarios</td>
<td>WP2</td>
<td>2</td>
<td>Report¹</td>
</tr>
<tr>
<td>M2.2</td>
<td>Report describing an initial blueprint of the system</td>
<td>WP2</td>
<td>2</td>
<td>Report</td>
</tr>
<tr>
<td>M1.1</td>
<td>Quarterly Management Report</td>
<td>WP1</td>
<td>3</td>
<td>Report</td>
</tr>
<tr>
<td>M3.1</td>
<td>Draft specification of the design of the virtual adapter (jointly with WP4)</td>
<td>WP3, WP4</td>
<td>3</td>
<td>Report</td>
</tr>
<tr>
<td>M4.1</td>
<td>Draft specification of the design of the virtual adapter (jointly with WP3)</td>
<td>WP3, WP4</td>
<td>3</td>
<td>Report</td>
</tr>
<tr>
<td>M2.3</td>
<td>Report describing the overall system requirements imposed by the scenarios</td>
<td>WP2</td>
<td>4</td>
<td>Report</td>
</tr>
<tr>
<td>M1.2</td>
<td>Quarterly Management Report</td>
<td>WP1</td>
<td>6</td>
<td>Report</td>
</tr>
<tr>
<td>M2.4</td>
<td>Report describing an improved blueprint of the system taking into account the system requirements</td>
<td>WP2</td>
<td>6</td>
<td>Report</td>
</tr>
<tr>
<td>M3.2</td>
<td>Draft specification of solutions for adding objects to the ecosystem</td>
<td>WP3</td>
<td>6</td>
<td>Report</td>
</tr>
<tr>
<td>M3.3</td>
<td>Draft specification of solutions for the creation of virtual links involving sensor nodes</td>
<td>WP3</td>
<td>6</td>
<td>Report</td>
</tr>
<tr>
<td>M4.2</td>
<td>Draft specification of addressing, unicast and multicast solutions</td>
<td>WP4</td>
<td>7</td>
<td>Report</td>
</tr>
<tr>
<td>M4.3</td>
<td>Draft specification of naming and discovery solutions</td>
<td>WP4</td>
<td>7</td>
<td>Report</td>
</tr>
<tr>
<td>M5.1</td>
<td>Draft specification of cloud and sensor services based on the application scenarios</td>
<td>WP5</td>
<td>8</td>
<td>Report</td>
</tr>
<tr>
<td>M1.3</td>
<td>Quarterly Management Report</td>
<td>WP1</td>
<td>9</td>
<td>Report</td>
</tr>
<tr>
<td>M3.4</td>
<td>Draft specification of solutions for the ecosystem management</td>
<td>WP3</td>
<td>9</td>
<td>Report</td>
</tr>
<tr>
<td>M4.4</td>
<td>Draft specification of application developer API (jointly with WP5)</td>
<td>WP4, WP5</td>
<td>9</td>
<td>Report</td>
</tr>
</tbody>
</table>

¹ Report = tangible output in the form of a document or slideset
| M5.2 | Draft specification of application developer API (jointly with WP4) | WP4, WP5 | 9 | Report |
| M3.5 | Release of a first version of components for ecosystem creation, virtual network creation and virtual adapter | WP3 | 12 | Software² |
| M5.3 | Extended specification of cloud and sensor services based on clean-slate protocol design and API specification work | WP5 | 13 | Report |
| M3.6 | Enhanced components for the virtual adapter (jointly with WP4) | WP3, WP4 | 14 | Software |
| M4.6 | Enhanced components for the virtual adapter (jointly with WP3) | WP3, WP4 | 14 | Software |
| M4.5 | Release of a first version of components for sensor data distribution, discovery and naming | WP4 | 14 | Software |
| M1.4 | Quarterly Management Report | WP1 | 15 | Report |
| M4.7 | Release of a first version of the application developer API | WP4 | 16 | Software |
| M2.5 | Refined architecture v1 based on findings in WP3, WP4 and WP5 | WP2, WP3, WP4, WP5 | 17 | Report |
| M3.7 | Enhanced components for adding sensor nodes and cloud resources to the ecosystem | WP3 | 17 | Software |
| M3.8 | Enhanced components for the creation of virtual links involving sensor nodes | WP3 | 17 | Software |
| M1.5 | Quarterly Management Report | WP1 | 18 | Report |
| M4.8 | Enhanced components addressing, unicast and multicast | WP4 | 18 | Software |
| M4.9 | Enhanced components for naming and discovery | WP4 | 18 | Software |
| M5.4 | Release of a first version of the cloud and sensor services | WP5 | 18 | Software |
| M3.9 | Release of components for the ecosystem management | WP3 | 20 | Software |
| M4.10 | Enhanced components for the application developer API (jointly with WP5) | WP4, WP5 | 20 | Software |
| M5.5 | Enhanced components for the application developer API (jointly with WP4) | WP4, WP5 | 20 | Software |

² Software = software components tested and released
<table>
<thead>
<tr>
<th>M2.6</th>
<th>First draft of the scenario selected for the demonstrator</th>
<th>WP2</th>
<th>22</th>
<th>Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>M5.6</td>
<td>Integration plan</td>
<td>WP5</td>
<td>22</td>
<td>Report</td>
</tr>
<tr>
<td>M1.6</td>
<td>Quarterly Management Report</td>
<td>WP1</td>
<td>24</td>
<td>Report</td>
</tr>
<tr>
<td>M3.10</td>
<td>Release of an enhanced version of all ecosystem creation and management components ready for integration in the demonstrator</td>
<td>WP3</td>
<td>24</td>
<td>Software</td>
</tr>
<tr>
<td>M4.11</td>
<td>Release of an enhanced version of the clean-slate protocols and API ready for integration in the demonstrator</td>
<td>WP4</td>
<td>24</td>
<td>Software</td>
</tr>
<tr>
<td>M5.7</td>
<td>Release of an enhanced version of the cloud and sensor services</td>
<td>WP5</td>
<td>24</td>
<td>Software</td>
</tr>
<tr>
<td>M5.8</td>
<td>Plan for conformance verification and interoperability testing</td>
<td>WP5</td>
<td>24</td>
<td>Report</td>
</tr>
<tr>
<td>M2.7</td>
<td>Refined architecture v2 based on findings in WP3, WP4 and WP5</td>
<td>WP2, WP3, WP4, WP5</td>
<td>25</td>
<td>Report</td>
</tr>
<tr>
<td>M5.9</td>
<td>Conformance verification and interoperability testing results</td>
<td>WP5</td>
<td>26</td>
<td>Report</td>
</tr>
<tr>
<td>M1.7</td>
<td>Quarterly Management Report</td>
<td>WP1</td>
<td>27</td>
<td>Report</td>
</tr>
<tr>
<td>M5.10</td>
<td>First integrated demonstrator</td>
<td>WP5</td>
<td>28</td>
<td>Prototype 3</td>
</tr>
</tbody>
</table>

3 Prototype = prototype integrated and running stable
1.3.3.4 Work package descriptions

<table>
<thead>
<tr>
<th>Work package number</th>
<th>WP1</th>
<th>Start date or starting event:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work package title</td>
<td></td>
<td>M1</td>
</tr>
<tr>
<td>Activity type</td>
<td>MGT</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Participant number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant short name</td>
<td>IBBT</td>
<td>JCP-Consult</td>
<td>VTT</td>
<td>UC</td>
<td>NEC</td>
<td>RMoni</td>
<td>LT</td>
</tr>
<tr>
<td>Person-months per partic.</td>
<td>5</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Objectives**

The project management structure has the main goal of controlling the overall progress of the work:

- To ensure that the project is conducted in accordance with EC rules,
- To reach the objectives of the project within the agreed budget and time scales,
- To coordinate the work of, and ensure effective communication between, the partners,
- To assess the quality of the work and the deliverables,
- To maximize the potential for exploiting results,
- To manage all technical, commercial, financial and administrative issues and particularly the identification of the actions needed to be taken in case of deviation from project plan.

**Description of work** (possibly broken down into tasks) and role of partners

**Task 1.1 – Project Organization and Management** [M1-M30 – Task Leader: JCP-Consult]

in charge of the daily management and control of the project, as well as the liaison with the Commission and external organizations

The objectives of this task are:

- To ensure the daily management of the Project to monitor the overall progress of the work, the production of the deliverables and deliveries at the agreed milestones;
- To ensure the communications between the Project and the Commission (representation at the regular Concertation meetings, participation to events organized by other projects, participation as requested to Commission organized events, etc.) and to external organizations;
- Set up and continuous update of an internal Collaborative web platform that will assist in the coordination of activities, sharing of technical documents and organizational issues.
- Resource management and mobilization in order to optimize the project efficiency. The project may be slightly modified or re-focus if necessary taking into account project evolution and risks.
- Reporting to Project Officer: Quarterly management reports, yearly review reports (APRR), cost claims, and a final report have to be prepared and submitted to the Project Officer.
- Managing knowledge and IPR

**Success criteria:** that the project produces in a timely fashion, within the budget and with the quality expected (in co-operation with T1.2) all its deliverables and that the project’s results are known and exploited outside the project.

**Partners:** IBBT, JCP-Consult
Task 1.2 – Project Quality Management [M1-M30 – Task Leader: IBBT]

A task specially devoted to the assessment of the quality of the work and the deliverables produced in the project

The objectives of this task are to ensure adequate quality of the outcomes of the project:

- Quality of the produced deliverables;
- Quality of the internal deliveries.

Success criteria: that the quality of the work is according to the specified parameters so as to minimize iterations during the specification, the development, test and integration process of the output of the various work packages

Partners: IBBT, JCP-Consult

Role of each partner: The administrative project management will be the responsibility of IBBT, supported by JCP-Consult.

Deliverables (brief description) and month of delivery

D1.1 - [M1] - Project Reference Manual: This document will incorporate all procedures concerning the technical and administrative management of the project, as well as the project rules and guidelines concerning management of foreground and IPR

D1.2 - [M1] - Project Quality Insurance Manual: This document will set the procedures to achieve deliverables and deliveries of adequate quality. Among others it will incorporate a Change Control Procedure.

D1.3 - [M6] - Knowledge Management Guide: This document will incorporate all rules and guidelines concerning management of foreground and IPR

D1.4 - [M12] - First period Progress Report

D1.5 - [M21] - Second period Progress Report

D1.6 - [M30] - Final report (including Third Period Progress Report)

Milestones (brief description) and month of delivery


M1.3 - [M9] - Quarterly Management Report (QMR)

M1.4 - [M15] - Quarterly Management Report (QMR)

M1.5 - [M18] - Quarterly Management Report (QMR)

M1.6 - [M24] - Quarterly Management Report (QMR)

M1.7 - [M27] - Quarterly Management Report (QMR)

The QMR will be in form of a condensed document highlighting the financial and human resources expenses so as the main technical progress and achievements of the project linked to the project status.
**Work package number** | WP2  
---|---  
**Start date or starting event:** | M1  
**Work package title** | Scenarios, requirements and architecture  
**Activity type** | RTD  
**Participant number** | 1 2 3 4 5 6 7  
**Participant short name** | IBBT JCP-Consult VTT UC NEC RMoni LT  
**Person-months per partic.** | 6 2 4 6 4 6 5

**Objectives**
- Provide ecosystem usage scenarios
- Identification of system requirements
- Design of a blueprint for the overall end-to-end system
- Guidance of work in WP3, WP4 and WP5

**Description of work** (possibly broken down into tasks) and role of partners

**Task 2.1 – Scenarios and derivation of requirements [M1-M30 – Task Leader: RMoni]**
This task will describe a number of scenarios (both business and end consumer scenarios) that can be mapped onto the ecosystem vision and that are of interest to end user and/or businesses. These scenarios will be analyzed in terms of actors, scale, traffic patterns, applications, data collection and usage... This analysis will provide a better understanding of the functionality the ecosystem has to fulfil and will form the basis to determine the requirements on the overall end-to-end system. The requirements will guide the design and implementation work in WP3, WP4 and WP5 and this work can be verified against these requirements. One scenario will be selected as the use case for demonstrating the final end-to-end system in WP5 task 5.4.

*Partners*: All partners will contribute to the definition of reference scenarios that can be mapped onto the general MENO concept and the derivation of the requirements on the system. Industrial partners bring in their expertise and knowledge to define realistic scenarios, having market relevance. RMoni is the leader of this task (and also WP leader).

**Task 2.2 – End-to-end system blueprint [M1-M30 – Task Leader: IBBT]**
This task will describe the high-level architecture of the complete end-to-end system. Starting from the project's ecosystem vision, a first rough design will be delivered in order to identify the major building blocks and their interactions and to kick-off and guide the work in WP3, WP4 and WP5. Based on the requirements identified in Task 2.1, the architecture will be refined in order to meet these requirements. The overall architecture will guide the implementation of the different components in WP3, WP4 and WP5 and their interfaces. At the same time, research observations in these WPs can influence the overall architecture.

*Partners*: All partners will contribute to the architectural design of the overall end-to-end system. Academic partners bring in their general knowledge on network virtualization and sensor node protocol design,

---

4 Since the tasks are very focussed, the participation of a partner in a task also defines its role in the task, namely contributing to the objectives defined in that task (unless stated otherwise or more concretely specified). In most cases, the exact assignment of subtask responsibilities (e.g. for implementation) will/can only be done during project execution.
whereas Industrial partners bring in their expertise on sensor and cloud services. Together, a realistic end-to-end system responding to industrial needs will be designed. The task will be led by IBBT.

**Deliverables** (brief description) and month of delivery

D2.1 - [M6] - Ecosystem application scenarios and their requirements: This document will describe a selection of relevant ecosystem scenarios and will derive the requirements they impose on the overall end-to-end system

D2.2 - [M9] - Initial end-to-end system blueprint: This document will describe the first blueprint of the overall end-to-end system, showing components, interfaces and how the interact to meet the requirements

D2.3 - [M21] - Enhanced end-to-end system blueprint: This document will start from D2.2 and will describe the enhanced blueprint of the overall end-to-end system, showing components, interfaces and how the interact to meet the requirements

D2.4 - [M24] - Demonstrator use case description: This document will describe in detail the use case that will be demonstrated in WP5 and requirements that can be used to verify the successful demonstration

D2.5 - [M30] - Final end-to-end system and its use cases: This document is a final summary of the end-to-end system designed and implemented, together with an overview of the application scenarios it can realize

**Milestones** (brief description) and month of delivery

M2.1 - [M2] - Report describing a selection of relevant ecosystem scenarios

M2.2 - [M2] - Report describing an initial blueprint of the system (major components)

M2.3 - [M4] - Report describing the overall system requirements imposed by the scenarios

M2.4 - [M6] - Report describing an improved blueprint of the system taking into account the system requirements

M2.5 - [M17] - Refined architecture v1 based on findings in WP3, WP4 and WP5

M2.6 - [M22] - First draft of the scenario selected for the demonstrator

M2.7 - [M25] - Refined architecture v2 based on findings in WP3, WP4 and WP5
Work package number | WP3 | Start date or starting event: | M1
--- | --- | --- | ---
Work package title | Ecosystem creation and management |  |  
Activity type | RTD |  |  
Participant number | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
Participant short name | IBBT | JCP-Consult | VTT | UC | NEC | RMoni | LT |
Person-months per partic. | 22 | 0 | 12 | 14 | 9 | 5 | 3 |

Objectives
- Design and implement solutions to include sensor nodes and cloud resources in the ecosystem
- Development of an easy and flexible ecosystem management solution
- Design and implement solutions for the creation of the virtual network
- Design (in cooperation with WP4) and development of the virtual network adapter

Description of work (possibly broken down into tasks) and role of partners

**Task 3.1 – Ecosystem participation [M1-M30 – Task Leader: IBBT]**
This task will design and implement solutions for adding members to the ecosystem. In particular, since our expertise on the creation of virtual IP networks will be used as a baseline to start from, this task will focus on how to add sensor nodes and cloud resources to the ecosystem. Since not everyone is allowed to take part in the ecosystem, a trust relationship needs to be established between the members of the ecosystem using cryptographical protocols (e.g. using certificates). For cloud resources, this extension could be straightforward. For sensor nodes, existing security solutions will be investigated and used for the purpose of adding selectively sensor nodes to the ecosystem by installing such a trust relationship on them.

*Partners:* IBBT and VTT bring in their expertise on virtual IP networks. NEC and RMoni bring in their expertise on the practical implementation on sensor nodes. Together they will develop solutions for the ecosystem participation. The task will be led by IBBT. IBBT is also work package leader.

**Task 3.2 – Ecosystem management [M4-M30 – Task Leader: VTT]**
This task will deal with the development of an ecosystem management solution. Adding devices to an ecosystem involves the establishment of a trust relationship. The implementation of this trust relationship is tackled in task 3.1 and will result in the installation of cryptographical material on the members. The whole process of dynamically adding or removing devices to the ecosystem falls under ecosystem management. In its simplest form, all devices could be added manually to the ecosystem, which is tedious and not scalable. Therefore, a user-friendly or even self-organizing (e.g. in function of the task to achieve) management system is needed to add nodes to or revoke nodes from the ecosystem. This task will design and develop such a system, which should be able to deal with devices that do not have a user interface and be as flexible as possible. This task will build upon the results from task 3.1.

*Partners:* NEC and VTT will contribute to the development of ecosystem management solutions. The task will be led by VTT, having experience on the management of virtual IP networks.

**Task 3.3 – Virtual network creation [M1-M30 – Task Leader: IBBT]**
This task will design and implement solutions for the creation of the virtual network. This virtual network consists of secure virtual links that are established between members belonging to the ecosystem. To
create such a secure link, the trust relationship between the members will be used. For non-sensor nodes we can again easily reuse our expertise on the creation of virtual IP networks. As such, the main focus will be on the virtual link establishment between sensor nodes and between sensor and non-sensor nodes. The resulting protocols must take into account the limitations of these sensor nodes. Interaction with task 3.1 will take place, since the used cryptographical protocols will influence the designed solutions. Further, properties of the virtual links will be collected and made available for use by other components.

**Partners:** IBBT, UC and LT will contribute to this task, which will be led by IBBT. IBBT and UC start from their existing work on the creation of virtual IP networks to extend it sensor nodes. LT contributes using their expertise on using symmetric cryptography for sensor nodes. Together, they will design and implement solutions for the creation of the virtual network.

**Task 3.4 (Cross-task with 4.1) – Virtual adapter design and implementation [M1-M30 – Task Leader: UC]**

This task will implement the lightweight convergence layer that hides the underlying virtual links. This will be realized in the form of a virtual adapter with a unique address that gives access to other nodes in the ecosystem over the different virtual links that have been established. Using this adapter, datagrams can be sent to all virtual links (broadcast) or a single virtual link (unicast). In addition, the collected virtual link properties will be exposed to the upper layers in a standardized way, hereby hiding the heterogeneity of different link technologies. The design must be lightweight, since it must run on devices with limited capabilities. On top of this adapter, the clean-slate protocols will be designed. To this end, the requirements imposed by the designers of these protocols must be taken into account carefully. Therefore, this task is a cross-task with task 4.1, where task 4.1 is responsible for bringing on the virtual adapter requirements and task 3.4 takes care of the implementation according to these requirements.

**Partners:** IBBT, RMoni and UC will contribute to the implementation of the virtual adapter. The task will be led by UC, which, together with IBBT, has experience on the design of a convergence layer. RMoni will assist in the design and implementation.

**Deliverables (brief description) and month of delivery**

D3.1 - [M8] – [Jointly with WP4] Specification of the virtual adapter design: This document describes the design of the virtual adapter on top of which the clean-slate protocols will be designed

D3.2 - [M10] – Specification of ecosystem participation and virtual network creation solutions: This document will describe the solutions needed to add sensor nodes and cloud resources to the ecosystem and how to use the resulting trust relationship to create the virtual network

D3.3 - [M16] – Specification of ecosystem management solutions: This document will describe solutions for managing the ecosystem

D3.4 - [M24] – Ecosystem creation and management implementation: This document provides an overall description of the implemented solutions for the creation and management of the ecosystem up to the creation of the virtual network

D3.5 – [M30] - Ecosystem creation and management implementation modifications: This document provides a summary of implementation changes needed for the realization of the demonstrator

**Milestones (brief description) and month of delivery**

M3.1 - [M3] - Draft specification of the design of the virtual adapter (jointly with WP4)

M3.2 - [M6] - Draft specification of solutions for adding objects to the ecosystem

M3.3 - [M6] - Draft specification of solutions for the creation of virtual links involving sensor nodes

M3.4 - [M9] - Draft specification of solutions for the ecosystem management

M3.5 - [M12] - Release of a first version of components for ecosystem creation, virtual network creation and virtual adapter

M3.6 - [M14] - Enhanced components for the virtual adapter (jointly with WP4)

M3.7 - [M17] - Enhanced components for adding sensor nodes and cloud resources to the ecosystem
| M3.8 - [M17] | Enhanced components for the creation of virtual links involving sensor nodes |
| M3.9 - [M20] | Release of components for the ecosystem management |
| M3.10 - [M24] | Release of an enhanced version of all ecosystem creation and management components ready for integration in the demonstrator |
Work package number | WP4  | Start date or starting event: | M1  
---|---|---|---
Work package title | Clean slate end-to-end protocol design  
Activity type | RTD  
Participant number | 1  | 2  | 3  | 4  | 5  | 6  | 7  
Participant short name | IBBT  | JCP-Consult  | VTT  | UC  | NEC  | RMoni  | LT  
Person-months per partic. | 20  | 4  | 13  | 16  | 15  | 5  | 6  

Objectives

- Deliver requirements for the virtual adapter design and implementation
- Develop a well-chosen set of protocols for the distribution of data, encompassing addressing, unicast and multicast
- Develop a well-chosen set of protocols for the discovery and naming of sensor nodes
- Design (in cooperation with WP5) and implement the application developer API

Description of work (possibly broken down into tasks) and role of partners

Task 4.1 (Cross-task with 3.4) – Virtual adapter design and implementation [M1-M30 – Task Leader: UC]

This task is a cross-task with task 3.4. As described in task 3.4, task 3.4 will implement the virtual adapter on top of which the clean-slate end-to-end protocols will be designed. To this end, this task will state the requirements this virtual adapter should meet in order to be able to implement the clean-slate end-to-end protocols and will as such take responsibility of the design of this adapter.

*Partners:* IBBT, RMoni and UC will contribute to the design of the virtual adapter (they also contribute the implementation as defined in task 3.4). The task will be led by UC. UC is also work package leader.

Task 4.2 – Distribution of sensor data [M3-M30 – Task Leader: IBBT]

This task will design and implement solutions for the distribution of sensor data. More specifically, an addressing scheme will be developed that has built-in multicast support. As such, it is possible to address an individual member or the group of all members that is interested in another member its data. Using this addressing scheme, basic functionality to enable best-effort and reliable unicast and multicast functionality will be implemented. For the multicast forwarding, the multicast addressing functionality will be used and mechanisms to easily establish multicast trees and connect them to this address will be implemented. During the design, existing solutions that could be of interest will be looked at. This set of protocols will allow the distribution of sensor data to or communication with sensors from non-sensor nodes in an end-to-end fashion and will form the basis for higher layer protocols that will make use of this functionality and that will be developed in task 4.3. This task will build upon the results from task 4.1 and will take into account the application requirements specified in task 2.1. It will also interact with task 4.3, since naming and addressing can influence each other and the protocols in task 4.3 will need to make use of the functionality designed here.

*Partners:* IBBT, NEC, UC, VTT and LT will together develop solutions for the end-to-end distribution of sensor data. IBBT, UC, VTT and NEC will all contribute their expertise on sensor network protocol design, complemented with the knowledge of LT on wireless radio networks. IBBT is task leader.
Task 4.3 – Sensor discovery and naming [M3-M30 – Task Leader: VTT]

This task will design and implement solutions for the assignment of friendly names to individual nodes of the ecosystem, groups of nodes, types of sensor data… These naming primitives must be in line with how sensor nodes are discovered, how sensor data is retrieved or how sensors are controlled, such that they can be easily used for the purpose of sensor node discovery, the second component of this task. In addition, when needed for the transmission of data, the names should be mapped to the addresses developed in task 4.2. Again, during the design, existing solutions that could be of interest will be looked at. Together this set of protocols will allow the easy discovery of sensor nodes according to a wide range of parameters and the easy addressing of sensor nodes using names. This task will build on the results from task 4.1 and will take into account the requirements from the scenarios derived in task 2.1.

Partners: IBBT, JCP-Consult, NEC, UC, VTT and LT will all contribute to this important task, designing discovery and naming solutions. They will bring together their expertise on sensor networks and network protocol design. NEC will also guide this work through their experience with sensor data capturing and processing. JCP-Consult will focus on the energy efficiency of the protocols. VTT will lead the task.

Task 4.4 (Cross-task with 5.1) – Application developer API [M6-M30 – Task Leader: VTT]

Task 4.2 and task 4.3 offer all primitives that are needed to discover sensor nodes and talk with them directly. As such, it offers the basis for the design of applications. The missing link between these primitives and designing applications, is an application developer API that makes these primitives available in easy-to-use way. Behind this API, an engine is needed that translates the calls and directs them to the naming, discovery and transport mechanisms. Of course, this API must meet the requirements of the application developers. To this end, this task is a cross-task with task 5.1. This task is responsible for the implementation of this API, based on the design requirements imposed by task 5.1. This task will build upon the results from task 4.2 and 4.3.

Partners: NEC, RMoni, UC and VTT will contribute to the implementation of this API. VTT will lead this task. The role of NEC, UC and VTT in task 4.3, will help designing (task 5.1) and implementing an API that is aware of the novel naming and discovery solutions. In addition, the involvement of NEC and RMoni in the implementation of cloud and sensor services is important to match the API to the requirements of these services.

Deliverables (brief description) and month of delivery

D4.1 - [M8] – [Jointly with WP3] Specification of the virtual adapter design: This document describes the design of the virtual adapter on top of which the clean-slate protocols will be designed
D4.2 - [M12] – Specification of clean-slate end-to-end protocols: This document will describe the novel clean-slate end-to-end solutions for the distribution of sensor data, discovery and naming
D4.3 - [M14] – [Jointly with WP5] Specification of the application developer API: This document will describe the specification of the application developer API on top of which applications will be designed
D4.4 - [M24] - Clean-slate end-to-end protocol implementation: This document provides an overall description of the implemented solutions for the distribution of sensor data, discovery, naming and the API
D4.5 – [M30] - Clean-slate end-to-end protocol modifications: This document provides a summary of implementation changes needed for the realization of the demonstrator

Milestones (brief description) and month of delivery

M4.1 - [M3] - Draft specification of the design of the virtual adapter (jointly with WP3)
M4.2 - [M7] - Draft specification of addressing, unicast and multicast solutions
M4.3 - [M7] - Draft specification of naming and discovery solutions
M4.4 - [M9] – Draft specification of application developer API (jointly with WP5)
M4.5 - [M14] - Release of a first version of components for sensor data distribution, discovery and naming
M4.6 - [M14] - Enhanced components for the virtual adapter (jointly with WP3)
| M4.7 - [M16] | Release of a first version of the application developer API |
| M4.8 - [M18] | Enhanced components addressing, unicast and multicast |
| M4.9 - [M18] | Enhanced components for naming and discovery |
| M4.10 - [M20] | Enhanced components for the application developer API (jointly with WP5) |
| M4.11 - [M24] | Release of an enhanced version of the clean-slate protocols and API ready for integration in the demonstrator |
Work package number | WP5 | Start date or starting event: | M6 |
---|---|---|---
Work package title | Ecosystem services and demonstration |
Activity type | RTD |
Participant number | 1 2 3 4 5 6 7 |
Participant short name | IBBT JCP-Consult VTT UC NEC RMoni LT |
Person-months per partic. | 6 0 7 6 20 14 11 |

Objectives
- Deliver requirements for the design of the application developer API
- Design an implementation of cloud services for efficient sensor data processing
- Integration of the solutions developed in WP3, WP4 and WP5 into a end-to-end system and validation of the developed solutions
- Demonstrating a specific application scenario

Description of work (possibly broken down into tasks) and role of partners

Task 5.1 (Cross-task with 4.4) – Application developer API [M6-M30 – Task Leader: NEC]
This task is a cross-task with task 4.4. As described in task 4.4, task 4.4 will implement the application developer API on top of which applications can be built. To this end, this task will state the requirements this API should meet in order to be able to implement the applications that will developed within this project. As such this task will be closely related with task 5.2, where the actual services will be developed. 

Partner: NEC, RMoni, UC and VTT will contribute to the design of this API. NEC and RMoni bring in their knowledge of the envisioned cloud and sensor services and their requirements on this API. NEC will lead this task and is also work package leader.

Task 5.2 – Cloud and sensor services design and implementation [M6-M30 – Task Leader: NEC]
This task will take care of the design and implementation of a selected set of cloud and sensor services. This task depends heavily on 5.1 since it will need to use the API, and will as such start simultaneously.

Cloud services
The cloud services part will design and implement the integration of cloud services into the MENO ecosystem as well the exporting of an ecosystem service as a Cloud service. This requires extensions to Cloud side to participate in the self-organized, automatic setup of the MENO ecosystem and scale according to the required processing and storage capabilities. Basic functionality such as Cloud access functionality will be included in nodes in the MENO ecosystem that uses cloud services. The services need to interwork with the clean slate protocols for utilizing the network features of the ecosystem (e.g, sensor discovery, sensor data exchange). For providing MENO services as cloud services, the project will examine the usage of a Cloud system to export the services and the impact on the MENO ecosystem.

Sensor services
The sensor services part will design and implement a number of sensor services required for the realization and demonstration of the final application scenario. The task will make use of the application developer API, in order to use the novel clean-slate protocols for sensor discovery and access, and the cloud services API, to get access to the services offered by the cloud. By doing so, generic functionalities for the aggregation, logging, triggering of events, sensor management (e.g. setting thresholds)... will be
designed and implemented, thereby cleverly using the newly offered functionality by the APIs. These services will enable to create processing chains that allow the easy collection and management of sensor data. On top, these data streams can be enriched or contextualized, for example with data coming from external services using the Cloud infrastructure to scale.

**Partners:** NEC will lead this task and will contribute to both the cloud and sensor services. RMoni and LT will use their industrial experience to contribute mainly to the design and implementation of sensor services.

**Task 5.3 – Integration and validation of solutions [M20-M30 – Task Leader: VTT]**

This task will integrate the solutions developed in WP3, WP4 and task 5.1 and 5.2 of WP5. Starting from the end-to-end system blueprint in WP2, the interfaces between the different components will be verified and tested. This verification procedure must ensure that all building blocks are interoperable. Next, when passing verification of the interfaces, the designed solutions will be validated by evaluating their functionality and verifying whether the meet the requirements that have been derived in task 2.1. If components fail verification of validation, this will be communicated to the respective work packages and tasks where corrective actions will be taken. The end result will be a stable and fully functioning end-to-end system on top of which services can be tested.

**Partners:** IBBT, NEC, RMoni, UC, VT and LT will all support the integration and validation of the solutions they have designed and implemented in WP3, WP4 and WP5. Task leader will be VTT.

**Task 5.4 – Demonstration of an application scenario [M20-M30 – Task Leader: RMoni]**

This task will demonstrate one of the application scenarios developed in task 2.1. One specific set of cloud and sensor services, designed in task 5.2, will be deployed on top of the end-to-end system integrated in task 5.3, showcasing the specific application scenario. As such, a specific demonstrator will be built that shows the feasibility and good functioning of the design solutions.

**Partners:** IBBT, NEC, RMoni, UC, VT and LT contribute to the demonstrator, with RMoni leading the task. RMoni and LT bring in their industrial experience on real products involving sensors to assist in the creation of a credible demonstrator.

** Deliverables (brief description) and month of delivery**

<table>
<thead>
<tr>
<th>Deliverable</th>
<th>Description</th>
<th>Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>D5.1</td>
<td>Initial specification of cloud and sensor services</td>
<td>[M10]</td>
</tr>
<tr>
<td>D5.2</td>
<td>Specification of application developer API</td>
<td>[M14]</td>
</tr>
<tr>
<td>D5.3</td>
<td>Enhanced specification of cloud and sensor services</td>
<td>[M15]</td>
</tr>
<tr>
<td>D5.4</td>
<td>Cloud and sensor service implementation</td>
<td>[M24]</td>
</tr>
<tr>
<td>D5.5</td>
<td>Verification, integration and interoperability testing report</td>
<td>[M28]</td>
</tr>
<tr>
<td>D5.6</td>
<td>Complete MENO end-to-end system demonstrator</td>
<td>[M30]</td>
</tr>
</tbody>
</table>

**Milestones (brief description) and month of delivery**

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Description</th>
<th>Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>M5.1</td>
<td>Draft specification of cloud and sensor services</td>
<td>[M8]</td>
</tr>
<tr>
<td>M5.2</td>
<td>Draft specification of application developer API</td>
<td>[M9]</td>
</tr>
<tr>
<td>M5.3</td>
<td>Extended specification of cloud and sensor services</td>
<td>[M13]</td>
</tr>
</tbody>
</table>

Proposal Part B: page [42] of [84]
<table>
<thead>
<tr>
<th>M5.4 - [M18]</th>
<th>Release of a first version of the cloud and sensor services</th>
</tr>
</thead>
<tbody>
<tr>
<td>M5.5 - [M20]</td>
<td>Enhanced components for the application developer API (jointly with WP4)</td>
</tr>
<tr>
<td>M5.6 - [M22]</td>
<td>Integration plan</td>
</tr>
<tr>
<td>M5.7 - [M24]</td>
<td>Release of an enhanced version of the cloud and sensor services</td>
</tr>
<tr>
<td>M5.8 - [M24]</td>
<td>Plan for conformance verification and interoperability testing</td>
</tr>
<tr>
<td>M5.9 - [M26]</td>
<td>Conformance verification and interoperability testing results</td>
</tr>
<tr>
<td>M5.10 - [M28]</td>
<td>First integrated demonstrator</td>
</tr>
</tbody>
</table>
Objective
The objective of this work package is to give appropriate visibility of the project through:
- Scientific and industrial dissemination via publications, public events, demonstrations...
- Exploring the possibilities to exploit the results achieved in the project
- Contribution to standardization by raising awareness of the project in different forums or bodies

Description of work (possibly broken down into tasks) and role of partners

Task 6.1 – Scientific and industrial dissemination [M1-M30 – Task Leader: JCP-Consult]
This task will take care of the scientific and industrial dissemination of the results generated in the project. The results achieved will be promoted via publications in well-chosen journals, conferences or workshops targeting a broad audience of interested parties that include both researchers and industry. In addition, smaller, more focused project workshops will be organized targeting a specific audience and promoting the project’s achievements as a whole. Exchanges with other FP7 projects with neighbouring work and research fields with similar focus will be performed. The project will actively participate in the activities organised by the European Commission with the objectives of providing inputs towards common activities and receiving feedback (e.g. from clusters and coordination groups). The details of dissemination activities and targeted events, workshops, collaborations envisaged with projects, collaboration with technology Platforms and Future Internet Assembly are given in section 3.2.1.1.

Finally, the outcome of the work will also result in a number of Master or PhD Thesis’s.

In order to structure the dissemination, the project will produce a “Project Communication and Dissemination plan”, including:
- A detailed calendar of events regularly updated and containing all relevant international and national conferences, exhibitions and events.
- A “communication kit”, including a leaflet and a poster that will be designed to disseminate project concept and objectives. These will be distributed at project workshops and to the conferences, where project members will participate.
- A project web site will be designed, implemented and maintained. It will include information about concepts, vision, objectives and expected outcomes as well as public documents, deriving from the project work, which will be regularly updated, offering links to other relevant sites and links to partners’ web sites.

Partners: All partners will contribute to the dissemination of the results. JCP-Consult will lead this task and is also work package leader.
**Task 6.2 – Exploitation and contribution to standardization [M1-M30 – Task Leader: NEC]**

This task will explore the possibilities of exploiting the results achieved in the project. Possibilities for exploitation could arise from the dissemination to industry, resulting in the establishment of further cooperation after the project’s ending. In addition, the project partners will make concrete plans to further exploit the results achieved, for example through very specific additional research activities tackling some specific problems that hinder commercialisation or through a valorisation project investigating the steps needed to turn the research results into a product. Also, the project aims to influence relevant standardization bodies or professional forums by raising awareness of the project’s results. This can be done through the publication of white papers or via the direct participation of partners in these bodies or forums. Targeted standard bodies and expected contributions are detailed in section 3.2.1.1.

*Partners: All industrial partners (NEC, RMoni, LT and JCP-Consult) will contribute to this task, which will be led by NEC.*

<table>
<thead>
<tr>
<th>Deliverables (brief description) and month of delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>D6.1: Project Web Site set-up [M2]</td>
</tr>
<tr>
<td>D6.2: Project Communication And Dissemination Plan: will set the major objectives of dissemination objective, and the planned dissemination actions [M6]</td>
</tr>
<tr>
<td>D6.3: Intermediate Dissemination Report [M18]</td>
</tr>
<tr>
<td>D6.4: Final Plan for the use and dissemination of foreground [M30]</td>
</tr>
</tbody>
</table>
### 1.3.3.5 Summary effort table

#### Table 3: Summary effort table

<table>
<thead>
<tr>
<th>Partic. no.</th>
<th>Partic. short name</th>
<th>WP1</th>
<th>WP2</th>
<th>WP3</th>
<th>WP4</th>
<th>WP5</th>
<th>WP6</th>
<th>Total person months</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IBBT</td>
<td>5</td>
<td>6</td>
<td>22</td>
<td>20</td>
<td>6</td>
<td>4</td>
<td>63</td>
</tr>
<tr>
<td>2</td>
<td>JCP-Consult</td>
<td>15</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>6</td>
<td>27</td>
</tr>
<tr>
<td>3</td>
<td>VTT</td>
<td>0</td>
<td>4</td>
<td>12</td>
<td>13</td>
<td>7</td>
<td>2</td>
<td>38</td>
</tr>
<tr>
<td>4</td>
<td>UC</td>
<td>0</td>
<td>6</td>
<td>14</td>
<td>16</td>
<td>6</td>
<td>4</td>
<td>46</td>
</tr>
<tr>
<td>5</td>
<td>NEC</td>
<td>0</td>
<td>4</td>
<td>9</td>
<td>15</td>
<td>20</td>
<td>4</td>
<td>52</td>
</tr>
<tr>
<td>6</td>
<td>RMoni</td>
<td>0</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>14</td>
<td>4</td>
<td>34</td>
</tr>
<tr>
<td>7</td>
<td>LT</td>
<td>0</td>
<td>5</td>
<td>3</td>
<td>6</td>
<td>11</td>
<td>3</td>
<td>28</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>20</td>
<td>33</td>
<td>65</td>
<td>79</td>
<td>64</td>
<td>27</td>
<td>288</td>
</tr>
</tbody>
</table>

This is also summarized in the following two figures.

![Figure 4: Effort breakdown per work package](image1)

![Figure 5: Effort breakdown per partner](image2)
1.3.4 Project flow

Figure 6: Project Flow
1.3.5 Risks and contingency plans

The structure of the MENO consortium and the defined work plan are such that no major deviations from the project’s objectives are to be expected. However, in order to guarantee the latter, the consortium has identified the following potential risks along with the corresponding contingency plans so that, should a risk actually materialise, the project as a whole will not be undermined.

**Partner problems**

Risk: If a partner leaves the consortium with unfinished work, it cannot be guaranteed that remaining partners will have the ability to complete the work with the expected achievements. The same is true for a key person with specific expertise that is leaving the project.

Contingency: The consortium includes a well-balanced composition of partners in the relevant fields. Of course, since an end-to-end system is being built, many components depend on each other in order to achieve the overall system (e.g. the virtual adapter and application developer API). In the work plan, care has been taken that multiple partners are working together on these crucial interfaces. If a partner leaves or underperforms, the other partner(s) can partially handle this and still provide the interface, although with reduced functionality. As such, most of the objectives can still be met. Objectives that still cannot be met will be cancelled and plans for replacement objectives will be submitted to the EC.

Risk: The lack of professionalism of some partners (incomplete system specification and architecture study, poor quality, insufficient documentation, incomplete unit testing of software/hardware components, insufficient integration testing/verification/validation, planning errors…)

Contingency: The consortium includes a well-balanced composition of partners with strong expertise in the relevant fields. Many of those partners have experience (e.g. from the MAGNET and MAGNET Beyond project) in designing architectures, specifying protocols, implementing these protocols and integrating them into a demonstrator. As such, the consortium definitely has shown its professionalism in the past. Next to this, the Project Leader continuously controls the project plan with its milestones and critical paths. These milestones are defined in a way such that these risks can be detected at an early stage. Together with the proper technical management, these risks can be mitigated.

**Expertise risks**

Risk: This can occur when a key person with a specific expertise is leaving the project

Contingency: The consortium is well balanced, in the sense that the partners have complementary expertise, but next to this also have partially overlapping expertise. Several partners have experience with virtual networks, sensor network protocols, network protocol design, integration… In case a person with a specific expertise is leaving, chances are high that the project will still meet its objectives. Only for the cloud services, key expertise only lies with NEC. Loosing this expertise would result in the cancellation of the related objectives and the establishment of a plan for replacement objectives, unless another group with this expertise from within one of the research institutes could take over the corresponding tasks.

**Project execution risks**

Risk: Key milestones or critical deliverables delayed

Contingency: The Project Leader will continuously follow the project plan with its milestones and critical paths in order to ensure a timely delivery and achievement of milestones and deliverables. In addition there is the monthly internal reporting. If possible deviations to the work plan might be observed, appropriate measures will be taken to deal with them long before the problem becomes too big and impossible to solve.
Risk: Too ambitious objectives (in terms of budget) or feasibility

Contingency: The project proposal has grown out of the work previously carried out by some partners. As such there is a solid basis to start from. For example existing network virtualization solutions will be reused and extended to include sensor nodes and cloud resources and to offer a layer on top of which the clean-slate design can take place. Also, regarding the clean-slate design, a well-chosen set of protocols will be designed offering only the basic functionality needed to demonstrate the concept. As such, from the very beginning of the project, care has been taken to define realistic objectives, both in terms of budget and feasibility.

Risk: Poor communication and cooperation between the partners

Contingency: At different levels in the project (task level, work package level, project level) care will be taken to guarantee the good collaboration and communication between partners. The project management will also facilitate and stimulate this by providing communication facilities and through the organization of meetings.

Agreement risks

Risk: Consortium partners cannot agree because of different interests

Contingency: The project management structure has been defined in such a way that in case of disagreement, decision-making procedures at different levels of the project management can be used in order to settle the disagreement.

Dissemination risks

Risk: No major interested parties for using the results are found

Contingency: The solutions targeted in this project can be deployed in several application scenarios and specifically in machine-to-machine communication. This is an area that will be growing enormously the next few years and in which there definitively will be a large interest from the academic and industrial world. Therefore, if the project achieves to meet its objectives, the chances are high that interest parties are found.

Competition risks

Risk: Competing solutions come up and make the results less valuable

Contingency: The concept proposed in this project is different from the traditional approach (and thus competing solution) involving gateways for the communication with sensor nodes. We have motivated why a different approach could be valuable, which is also confirmed by the industrial partners in this consortium. The consortium has the expertise to reach the project’s objectives and demonstrate the feasibility of the approach we propose. In that sense, we want to come up with a competing solution having advantages over today’s solutions and tailored to the Future Internet vision. If similar approaches would come up, this would be good since it would confirm the potential of the proposed concept. In that case, it is up to the consortium to make use of its expertise, to deliver results that stand out.

Having in mind that some risks may have an impact on the project schedule and project objectives and finally may lead to contractual issues, the management process shall identify and monitor all internal and external risks for the project and take appropriate measures. Mitigation is undertaken at the appropriate level in the project organisation: work packages, Project Management Committee or General Assembly in accordance with the rules defined in the Consortium Agreement.
2 Implementation

2.1 Management structure and procedures

The management of the project has the following aims:

- To reach the objectives of the project within the agreed budget and time scales,
- To ensure that the project is conducted in accordance with EC rules,
- To maintain communications with the Commission,
- To ensure effective communication between the partners and to solve any problem or conflicting situation,
- To coordinate the work of the partners,
- To set the quality policy, including quality objectives for the project as well as of the deliverables,
- To manage properly foreground and IPR matters,
- To maximize the potential for exploiting results,
- To ensure that decisions are made on the basis of data and factual information
- To ensure that an infrastructure is set up in order to support the above

The mandatory Consortium Agreement (CA) which main terms have been discussed and agreed during this proposal phase will be established before the start of the project; it will be maintained throughout the project’s time life. In CA the detailed rules regarding composition of the MENO project management bodies and their decision-making procedures will be described. In addition the CA will define rights and obligations of the partners including, but not limited to, their liability and supplementing the provisions of the EU Contract concerning Access Rights. The CA will be supplementing, but not conflicting with the provisions of the EU Contract. In summary the Consortium agreement will follow the IPCA model, with some adaptations in accordance with the rules and organisation defined below.

The three following deliverables produced at an early stage will establish the rules of project management:

- The Project Reference Manual will set the day to day rules of the project: documents and deliverables handling, project planning and manpower, meeting organisation, internal reporting and information management, external information management, list of personal with corresponding responsibilities. The document will be updated throughout the project life
- The Project Quality Assurance Manual will define the quality assurances and quality control rules and guidelines to follow, including documentations and information to provide; it will also include the different internal milestones in the R&D process and describe the change control procedures.
- The Knowledge Management Guide, which details beyond the terms of the EC Grant Agreement the internal project rules and guidelines concerning the management of foreground and IPR.

All the deliverables, the work and resources effort for the internal project management is covered and described in WP1 description.

2.1.1 Management structure and decision-making structure

The following light Project Management structure adapted to the project size, and already implemented with success in past similar projects has been agreed among the partners.
The operational groups are the following:

- **The General Assembly**, chaired by the coordinator, approves the project budget and the general annual objectives.
- **The Project Management Committee**, chaired by the Project Technical Manager is the effective executive body of the project.
- **The WP technical groups** (chaired by the WP Leader) ensure the day-to-day WP technical work.

The Project office supports the several operational groups in all non-technical tasks.

### 2.1.1.1 General Assembly (GA)

The role and responsibilities, the rules, the decision making procedures of the General Assembly are extensively detailed in the Consortium Agreement.

#### Composition

GA comprises one representative of each Partner. Each Partner shall nominate a senior representative, with budget responsibility, enabling to make consistent decisions and to represent contractor’s interests. GA is chaired by the Coordinating Partner.

#### Role and responsibilities

The role of the General Assembly is to ensure the official follow-up of the project and to take the major decisions mainly on:

- Contract and Consortium Agreement amendment,
- Termination of the contract and actions against underperforming partners,
- Budget follow-up and transfers,
- Selecting new contractors to enter contract & consortium agreement;
- Deciding major changes in the project;
- Deciding on technical roadmaps for the project;
- Approval of certain decisions of the Project Management Committee.

#### Meetings
The GA shall be convened by default once a year. The GA ordinary meetings shall be convened together with a project meeting. A General Assembly extraordinary meeting can be called at any time by the coordinator or any partner under the terms and rules of the Consortium Agreement.

**Decision making procedures**

Decisions will be taken by consensus whenever possible; however, some decisions related to budget and conflict resolutions will be taken by voting. In voting each Partner has one vote.

2.1.1.2 *Project Management Committee (PMC)*

**Composition**

The Project Management Committee shall consist of:

- The MENO Project Technical Manager
- The Work-package leaders.

**Role and responsibilities**

The Project Management Committee has the responsibility for the overall project progresses (objectives, schedule, milestones, etc) and results in full conformance with the decisions of the General Assembly. The responsibilities of the PMC will address the following issues:

- The Coordination, monitoring and control of the progress of the work in the project,
- The insurance that the project remains innovative, forward looking,
- The follow-up of Work-packages activities,
- The quality control on the work produced,
- The Approval of the deliverables,
- The definition and implementation of actions in case of deviations from project plan
- The Launch call for tenders if needed
- The coherence between the partners dissemination and communication activities
- The Management of foreground and IPR.

**Meetings**

Physical meetings of the PMC are organized every 3 months during the Consortium meetings. In between teleconferences are organized on a regular basis or on request.

**Decision making procedures**

Decisions will be taken by consensus whenever possible. No voting will occur within the Project Management Committee. In case of conflict or for decisions beyond the PMC responsibilities’ level, the PMC will refer to the General Assembly.

2.1.1.3 *Work Package Technical Groups*

**Composition**

Each WP technical Group is composed of all the member of the considered WP and is chaired by the WP leader. The WP leader (WPL) is designated at the project start by the Project Technical Manager.

**Role and responsibilities**

In practice the following operational work of the project is performed in the WP Technical groups, under the responsibility of the WPL:

- To take the technical guidelines from the Project Management Committee,
- To make the further technical choices when implementing these directives,
- To report on the activity to the Project Management committee,
- To follow-up the timely achievement of milestone and production of deliverables,
• To manage the day-to-day activity of the considered WP.

When needed and on request, the Project Technical Manager will attend the meeting.

WP1 does not have its own technical group as WP1 matters are treated by the project Office under the responsibility of Michèle Wilmet from JCP and the Project Technical Manager.

Meetings
WP Technical groups meetings occur at least at the same time and location than the Project Management Committee meetings. They are convened just before the project Management Meeting to enable reporting and resolution of issues there. In addition, WP meetings can be called and organized by each WP leader when needed to achieve the technical work. In between teleconferences are organized on a regular basis or on request.

Decision making procedures.
All decisions are consensus driven; no voting is allowed. Decisions that cannot be solved at the WP technical group level will be escalated to the Project Management, then to the GA where a vote would occur.

At this stage of the proposal, the table below summarizes WP leadership.

Table 4: Work package leadership

<table>
<thead>
<tr>
<th>Work Package</th>
<th>Company</th>
<th>Person in charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>WP1</td>
<td>IBBT</td>
<td>Ingrid Moerman</td>
</tr>
<tr>
<td>WP2</td>
<td>RMoni</td>
<td>Mark Kestens</td>
</tr>
<tr>
<td>WP3</td>
<td>IBBT</td>
<td>Jeroen Hoebeke</td>
</tr>
<tr>
<td>WP4</td>
<td>UC</td>
<td>Luis Sanchez</td>
</tr>
<tr>
<td>WP5</td>
<td>NEC</td>
<td>Anett Schülke</td>
</tr>
<tr>
<td>WP6</td>
<td>JCP-Consult</td>
<td>Emmanuelle Malésys</td>
</tr>
</tbody>
</table>

2.1.1.4 Project office
A Project Office (PO) comprising a staff familiar with administrative, legal, financial, communication and IPR issues will support the several operational groups in all the above responsibilities. The project office tasks will be managed by JCP-Consult staff (Michèle Wilmet and an administrative assistant). The Project Office will get advises from financial, legal, IPR specialists whenever required.

The Project Office:
• Assists the Project Coordinator in all the General Assembly preparation and follow-up tasks,
• Assists the Project Technical Manager in the project management tasks (meetings, teleconferences…),
• Assists the WP leaders in all the organisational tasks (meetings, teleconferences…),
• Ensures the follow-up and respect of all the procedures and deadlines,
• Manages the delivery and the follow-up of administrative and financial documents,
• Acts as a help desk for any partners relevant requests regarding their participation in the project
• Maintains a high level of communication within the Consortium
2.1.2 Management roles

**Project Coordinator**

The Project Coordinator co-ordinates all the communication channels within all the partners to ensure progress and quality in the work and provides the Commission with technical, managerial and financial information. In this role, he is assisted by the Project Office and the PMC (see above).

The project Coordinator will be IBBT represented by Ingrid MOERMAN.

The Project Coordinator will act as the unique focal point for contacts and co-ordination with the European Commission; together with the Project Technical Manager, he will be a contact point with the other relevant ICT projects, and external relationship with relevant bodies and other related activities.

The Project Co-ordinator chairs the General Assembly. His major tasks are:

- Supervision of the overall project progress
- Preparation of the General Assembly, production of the minutes and follow-up of its decisions
- Consortium Agreement coordination
- Collection of the audit certificates and supervision of distribution of EC’s payments to partners
- Preparation of the reports, cost statements and project documents required by the EC
- Organisation of EC review meetings
- Supervision of IPR and knowledge management (with relevant advice of a Legal Council)
- Representative of the consortium to events
- Coordination of the dissemination and communication activities

The Project Coordinator is supported in the above tasks by the Project Office and the Project Technical Manager.

**Project Technical Manager**

The Project Technical Manager coordinates the activities of all partners in the project according to work plan.

The Project Technical Manager is Jeroen HOEBEKE (IBBT). He will have the following responsibilities:

- Chair of the Project Management Committee
- Liaisons between the Project Management Committee and the General Assembly
- Technical relationship and coordination with other relevant R&D projects
- Supervision of the overall technical progress of the project
- Management of the risks, monitoring and update of the risk table
- Consolidation of the technical reports
- Follow-up and coordination of all technical work-packages

The Project Technical Manager is assisted in all the non-technical tasks by the Project Office.

2.1.3 Operations and communication tools

**Planning**

Drafting coherent plans for the project work is an essential prerequisite to enable the work to progress. The current document only presents a high-level overview of the project, setting out the ground rules on which the project will proceed in terms of objectives, technical approach and time scales.

At the project start a consolidated planning will be produced and maintained by the Project Office. A detailed work plan will be produced for each sub-task level to avoid redundancy in tasks, to ensure all
the tasks are covered and to allow an efficient follow-up of progress. The work plan can be revisited only with the approval of the PMC.

**Conflict resolution**

A clear decision making procedures will allows a simple conflict resolution process.

- When a conflict occurs in a WP technical group, consensus seeks to solve the problem. If the problem cannot be solved, the WP leader prepares a description of the problem and its possible solutions and transmit it to the PMC;
- If consensus cannot be reached within the PMC, the Project Technical Manager escalates it to the General Assembly and a vote occurs, requiring a simple majority.
- Extraordinary GA meetings can be organised using audio-conference (with the terms and delay defined in the Consortium Agreement)
- Email voting is allowed (again according to the rules defined in the Consortium Agreement).

**Meetings and Travel management**

Three plenary meetings are organised at minimum per year; they will be preceded by WP group meetings and ad-hoc technical meetings. The grouping of the meetings guarantees maximum efficiency: immediate inputs and feedbacks from one meeting to another one, possibility to call ad-hoc meetings, easy informal contact between all parties concerned, and minimum travel cost.

At the project start, the PMC (Project Management Committee) defines a provisional planning either for meetings and teleconferences. The calendar (time and place) of the various meetings for one year will be defined during the kick-off meeting, and from then, one year in advance.

Regular Teleconferences are scheduled. They will occur with the minimal following period:

- WP technical group: once per month
- Project Management Committee: Once a month, 1 week after WP teleconferences.
- Project Office: one teleconference with all the partners will be organised at least every quarter after the release of the QMR.

**2.1.4 Monitoring, reporting progress and documenting results**

**Deliverables & Documentations**

Document management rules and guidelines (Template, classification, numbering and distribution limitations) will be contained in the Project Management Manual produced by WP1 at the project start (Month 1). The review/approval procedures will be defined in the Project Quality Assurance Manual (Month 1).

All project documentation will be stored electronically in the collaborative platform and as paper copies. The usual tools (Fax, E-mail, collaborative tool) will be used for the exchange of documents/information. They will be complemented when needed by audiovisual conference systems.

**Reporting Process**

An internal Monthly reporting will be requested allowing each partner to keep his progress on track. Monthly reporting will be done the week before PMC teleconferences. Quarterly and yearly reporting to the Commission will follow the rules defined for FP7.

**The MENO Collaborative tool**

The Consortium will use for its internal communication an interactive Web collaborative Platform. This site is secured and enables the consortium to manage the diffusion of the information, to convene to meetings and teleconferences, to follow resources and allow easy exchanges between partners. It can be made accessible for the Commission and reviewers with personal level of access rights.
### 2.2 Individual participants

<table>
<thead>
<tr>
<th>Participant Number</th>
<th>P01</th>
<th>Participant short name</th>
<th>IBBT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant full name</td>
<td>Interdisciplinary Institute for Broadband Technology</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Short description of the organisation**

IBBT is an internationally recognized multidisciplinary ICT research centre (looking at technological, legal, business and sociological aspects) and enables accelerated development and exploitation of new ICT products and services in strategic sectors in Flanders. The INTEC Broadband Communication Networks (IBCN) research group is a leading telecommunications and software research group based in Ghent, Belgium, belonging to the Department of Information Technology (INTEC) of the Ghent University (UGent) and to IBBT.

**Attributed tasks**

IBBT will act as the coordinator of the MENO project and will deliver the project coordinator and project technical manager. Further, IBBT will contribute to the scenarios, requirements and design of the overall end-to-end architecture. IBBT will also focus on the creation of the ecosystem, in particular on the establishment of the virtual network and the development of the virtual adapter on top of which the clean-slate design will take place. Effort will be put into the design of network solutions for the end-to-end distribution of the sensor data within the ecosystem. We will contribute to the integration and validation of the designed solutions and the setup of an end-to-end demonstrator. Finally, IBBT will disseminate its research results in journals, conferences and workshops and will explore exploitation possibilities.

**Relevant experience**

IBCN’s research scope can be categorized in following domains: (1) Advanced network architectures and protocols; (2) Emerging mobile and wireless networks; (3) Innovative service delivery architectures & software applications. The group has participated in numerous EU projects, is frequently partnering with local ICT industry and takes part in national and Flemish research programs. The IBCN group combines theoretical top-down research and development with validation, experimentation and proof-of-concepts.

For MENO specifically, IBBT provides its expertise regarding the design, development, integration and deployment of secure and self-organizing virtual IP-based networks (resulting from its participation in EU projects such as IST MAGNET, IST MAGNET Beyond, ITEA2 Usenet and in several national projects such as IBBT Transecare and IBBT VIN). Next to this, IBBT will bring in its expertise related to the development of networking protocols (MAC, routing, cross-layer design) for sensor nodes. Also, IBBT has experience with the design of a modular development framework for sensor nodes that simplifies protocol design. Finally, IBBT has successfully deployed a large-scale Wi-Fi and sensor network test bed (+ 200 nodes).

**Profile of key personnel**

Prof. Ingrid Moerman is a professor at Ghent University. Since 2006 she joined IBBT, where she is coordinating several interdisciplinary research projects. She is currently involved in the research and education on mobile & wireless communication networks.

Dr. Jeroen Hoebeke received his Ph.D. degree in engineering (computer science) from Ghent University, Belgium in 2007. He is active on virtual IP networks, combining overlay networks, self-organisation and ad hoc networking techniques.

Next to this, the work in MENO will be supported by 2 Phd students or project researchers.
Participant Number: P02  
Participant short name: JCP  
Participant full name: JCP-Consult SAS

Short description of the organisation

JCP-Consult is a French SME created in 2002 with a strong technical experience in broadband and audio-visual technology and economics. JCP-Consult individuals have contributed to standardisation in these technologies through chairmanship of different groups and active participation to several bodies (DVB, DAVIC, ETSI ECCA, and CableLabs); they have a long experience in technical, administrative and legal aspects of R&D European Projects’ set up & management. JCP-Consult has also the expertise of setting-up workshops and conferences both on the organisational and technical side.

Attributed tasks

In the MENO project, JCP will support the management activities in WP1, the set-up and animation of the web site and organisation of the dissemination activities described in WP6.

JCP-consult will also work on the general architecture and business implications of the MENO project in the WP2, and on high-tech algorithms for energy efficiency in WP4.

Relevant experience

On management and dissemination aspects, JCP-C individuals have a long experience in R&D European (ACTS, Eureka, ICT, CELTIC and ITEA) and national projects, mainly in the audio-visual and network areas. JCP was involved in management of FP6/7 Medianet (IP), BroadWAN (IP), BREAD, CHORUS, PHENIX, 4NEM (CSA), Diconet, Mobithin (STREPs). JCP-Consult will be Coordinator of OASE (IP), Accordance (STREP), CHORUS + (CCA) and partner in I-Search (STREP), 4 projects from call 4 starting in 2010.

They have also expertise in setting-up workshops and conferences both on the organisational and technical side. They were/are involved in organisation of Broadband Europe, NEM Summit, CHORUS conferences (audiovisual search), and many workshops on VOIP, convergence, IMS for European projects.

Profile of key personnel

Jean-Charles Point has a large management experience and expertise in the cable, wireless and fiber access areas, as well as in IP architectures for multimedia services, and has exercised the several key positions in the Industry prior to build-up JCP-Consult. He has been involved for more the 12 years in European and national initiatives (managing financed programme participation in Thomson) like ACTS, Eureka, ITEA, IST, RIAM. Jean-Charles holds a Master of Science degree and graduated as “civil engineer telecommunication” in Faculté Polytechnique, Mons, Belgium.

Dr. Xavier LE BOURDON is a technical expert in pervasive computing: low-range wireless communications (Bluetooth, WiFi, RFID…), context-aware services (geolocalisation, metadata management…), and mobile phone applications. Interested in crowdsourcing, he has initiated and he leads some successful international projects on the Internet, with high scalability and security concerns. Xavier holds an engineer degree in INSA of Rennes and a Ph.D in computer science from the INRIA/IRISA laboratory.

Michèle Wilmot joined JCP-Consult 6 years ago as Administrative Manager. Since then, she is deeply involved in the Administrative management tasks related to several EC projects (Bread and Chorus in FP6, Diconet and MobiThin in FP7).

Emmanuelle Malyes joined JCP-Consult in 2007; she has initially a degree and Master in legal affairs and project management. She has been working since then in dissemination and IPR issues of FP6 project CHORUS, and FP7 project DICONET.
Participant Number | P03 | Participant short name | VTT

Participant full name | Technical Research Centre of Finland

Short description of the organisation

VTT Technical Research Centre of Finland is a governmental multidisciplinary expert organisation that carries out technical and techno-economic research and development work. With approx. 2700 employees, VTT provides a wide range of technology and applied research services for its clients - private companies, institutions and the public sector. In the telecommunications field, VTT is working on methods and algorithms needed in realisation of telecommunication networks, wireless services, architectures as well as on implementation technologies for network elements and terminals.

Attributed tasks

VTT contributes to the design and implementation of the ecosystem creation and management functions; to clean-slate end-to-end protocol design within the ecosystem; to the integration and interoperability testing of the developed software components; and to the validation and performance evaluation of the overall prototyped MENO solutions.

Relevant experience

VTT has participated in several projects (e.g. EU projects MAGNET, MAGNET Beyond, Ambient Networks, and CRUISE NoE) that have addressed secure virtualisation of network connections to form a (Private) Personal Network, and performed research into wireless sensor networks. As a result of these projects, VTT has increased the relevant expertise in network protocol design and development, and the integration of software components to working pilot environment.

Profile of key personnel

Pertti Raatikainen received his PhD degree in information and communications technology from Helsinki University of Technology in 1996. He started his working career in Nokia Telecommunications as R&D engineer in early 1980s. In mid 1980s, he joined VTT where he held several positions: research scientist, senior research scientist and research group manager. In mid 1990s, he worked two years for Teleste Ltd as product development manager. In late 1990s, he returned to VTT and is currently the technology manager of Network Technologies knowledge centre. His research interests are focused on broadband network technologies and, especially, on switching and routing techniques.

Kimmo Ahola (born 1972) started studying computer science in 1992 at the University of Jyväskylä. He joined Technical Research Centre of Finland (VTT) in 1996 as Research Trainee and continued his work with Internet protocols and multimedia transmission over Internet. Besides his work he studied towards his M.Sc. degree, which he received in 1997. From 1997 to 2001 he worked at VTT as Research Scientist. Since 2001 he has been working as Senior Research Scientist and starting from 2006 also as a Team Leader in Adaptive Networks team. He has participated in several national R&D projects. He has also participated and lead software development in Eurescom project Caspian, EU CONTEXT, MAGNET and MAGNET Beyond projects.
Participant Number | P04 | Participant short name | UC |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant full name</td>
<td>Universidad de Cantabria</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Short description of the organisation

The Network Planning and Mobile Communications Laboratory group is constituted by 4 professors and 5 assistant professors. Its research activities are currently supported by 20 undergraduate students carrying out their degree thesis within this group and 10 are pursuing their Ph.D. Its research activity is related to wireless IP, network management, mobile networks, advanced data transmission techniques and traffic engineering. Expertise areas are the following: 1) Protocols and architecture design and implementation for mobile communication networks; 2) Context management and context-aware solutions from network to application level; 3) Sensor networks middleware

Attributed tasks

UC will work on the definition of the end-to-end system and derivation of technical requirements and required functionalities. The focus of UC’s contribution will be on the development of a middleware component that hides the sensor specific features and presents a common interface to the upper levels. Besides, UC will contribute to the addressing and naming protocols design. In this sense, our approach is on the intertwining of these two aspects so that service development could be made on a more straightforward way. Furthermore, UC will work on the integration of the prototype implementation of the components developed on the previous items. Finally, UC will contribute to disseminate project research results thus raising public awareness of the project

Relevant experience

Our expertise is mainly based in implementation of advanced network optimization algorithms, and is supported by the active and successful participation in a large number of European projects.

In GOLLUM, we developed the middleware to support heterogeneous wireless technologies configuration and management. Special attention was put on the coexistence of sensor and high capable networks technologies, developing an API to interact with IEEE 802.11 and Zigbee-based sensor networks. In MAGNET and MAGNET Beyond, we worked on the development of the personal networking paradigm; the specification and implementation of mechanisms to support coexistence of heterogeneous wireless technologies, and optimization of network performance through context awareness. Additionally, we worked on the implementation of the Personal Networks Federation concept. In this project, we coordinated the creation and settlement of a project wide test bed resulting from the coordination and federation of laboratories from 5 different partners.

In these projects we have played a key role both on specification and design, and on the implementation and integration of proof-of-concept demonstrators and pilot systems.

Profile of key personnel

Prof. Luis Muñoz received both the Telecommunications Engineering and Ph.D. Degree by the Polytechnical University of Cataluña (UPC). He is head of the Networks Planning and Mobile Communications Laboratory at the University of Cantabria. His research focuses on heterogeneous wireless multihop networks and applied mathematical methods for telecommunication.

Dr. Luis Sánchez is assistant professor at the Dept. of Communications Engineering at the University of Cantabria. He is active on meshed networking on heterogeneous wireless scenarios and optimization of network performance through cognitive networking techniques.

Dr. Roberto Sanz is professor at the University of Cantabria since 2002. He has been involved in different national and international projects, the latter within the ACTS and IST programs, related to voice and data transmission over wired and wireless infrastructures.
Participant Number | P05 | Participant short name | NEC |
---|---|---|---|
Participant full name | NEC Europe Ltd. |

Short description of the organisation

NEC Europe Ltd. established the Network Laboratories in Heidelberg, Germany in 1997 as NEC's research facility focusing on networking in Europe. Research and development functions are integrated into the same organization to shorten the time to market of cutting-edge network technologies. The laboratories place special emphasis on solutions meeting the needs of NEC's European customers.

The Heidelberg labs focus on software-oriented research and development for the next generation Internet. New communication architectures and protocols supporting multimedia and mobility over the Internet, together with intelligent Internet services, are the core of our work. A market research team continuously analyses market trends and market requirements to ensure that R&D activities address actual market needs.

During the last decade the laboratories have become a recognised partner in various collaborative research and development projects conducted jointly with European service providers, technology vendors and academic research groups. The labs are leading contributors to the European Union’s Information & Communication Technology program (EU ICT), as well as various national German R&D activities. Our staff actively contributes to scientific conferences as well as standard organisations like IETF, 3GPP, TISPAN or OMA. NLE has participated in many European R&D projects, e.g., in DAIDALOS, Ambient Networks, MobiLife, SPICE, MAGNET Beyond, and UbiSec&Sens in FP6, and in 4ward, Trilogy, SWIFT, SENSEI, WSAN4CIP, ICT-iNEM4U and ICT-OPEN in FP7.

Attributed tasks

NEC contributes to the design and implementation of the ecosystem creation and management functions, sensor data distribution, sensor discovery and naming, to the Application Developer APIs, to the Cloud service design, as well as to demonstration of application scenarios.

Relevant experience

NEC has a long history of experiences in sensor data capturing, processing, and usage for context applications. NEC has worked on context data management in projects like MobiLife, SPICE, Daidalos, UbiSec&Sense, WSAN4SIP and others. NEC is a leading contributor to the specification of the OMA Next Generation Services Interface and the Context API in particular. Furthermore, NEC is a providing xaaS solutions to IT companies and Operator. In the Cloud Computing filed, NEC has a long history on NGN SDP platform using IMS and Soa/grid technologies.

Profile of key personnel

**Dr. Anett Schülke** is Chief Researcher at NEC Laboratories Europe, NEC Europe Ltd. She received her PhD in Physics in 1995 from Dresden University of Technology. From 1996 to 1998 she was awarded a DAAD fellowship for the LBNL, California/USA and worked until 1999 as a Postdoctoral Fellow. Anett's research focus at NEC Laboratories Europe are service creation and delivery technologies (SDP), IP Multimedia Subsystem (IMS), NGN Grid Technologies, and smart power grid in telecom and data networking research, design and development. Anett published in several international conferences, presented tutorials on IMS and SDP at research and marketing events, and has been involved in TPC for IEEE conferences. She represents NEC in OMA standardization, TMF SDF group as well as in GSMA.

**Dr. Martin Strohbach** is research scientist at NEC Laboratories Europe in Heidelberg, Germany. Since 2008 he is leading a research project on Pervasive Display Networks that focuses on advancing existing Digital Signage solutions with context technologies. Martin holds a Ph.D. from Lancaster University where he actively contributed to several European projects (FP6 CoBiS, Smart-its, SPCIE, FP7 SENSEI) as well as UK research projects (EQUATOR and NEMO). He has published in key international conferences and workshops such as UbiComp and EWSN and co-organized workshops at UbiComp and ICDCS.
<table>
<thead>
<tr>
<th>Participant Number</th>
<th>P06</th>
<th>Participant short name</th>
<th>RMoni</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant full name</td>
<td>RMONI wireless n.v</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Short description of the organisation**

RMONI is an SME that develops and manufactures hardware and software for wireless registration and monitoring of crucial control parameters. The company has a track record in the design and rollout of wireless sensor networks and offers solutions in three domains: temperature monitoring during transport and storage of food products, monitoring of health and energy related parameters in public buildings, and environmental monitoring for the pharmaceutical industry.

**Attributed tasks**

RMONI participates in the MENO project as an industrial partner to offer its expertise on the practical implementation of wireless sensor networks, and participate in the definition of future requirements. This will lead to inputs for the overall end-to-end architecture. RMONI will participate in the ecosystem, co-defining the virtual network and implement the new virtual adapter. The network layer will be studied including solutions for sensor setup and data collection. Prototypes for an end-to-end demonstrator will be developed and integrated to validate the designed solution. RMONI will disseminate and commercially valorise its results.

**Relevant experience**

RMONI's expertise is both on the hardware and software development for Wireless Sensor Networks. Our expertise lies in the implementation of the IEEE802.15.4 protocol in a real-life application monitoring trucks and warehouses. To this end, a proprietary point-to-multipoint network layer has been developed. Further, RMONI has implemented Zigbee 2007 pro in a product range suited for buildings and storage applications. So we have a lot of experience on the rollout and commissioning of such networks, including site surveys and redundancy schemes. All these applications are governed by proprietary software applications, which are either webbased, stand alone PC based or server based.

RMONI is a partner in the ITEA USENET project, which studies a VPAN layer up to the WSN Gateway. An end-to-end solution for sensors, such as studied in MENO, may offer competitive advantages over a traditional Endpoint-Router-Gateway solutions as offered today.

**Profile of key personnel**

**Ir. Bart Meekers** has a degree in electronics/telecommunication at Leuven University (1993). He started his career as a researcher at Siemens, published various papers and hold a patent related to fiber optic communications. In 1995, Bart Co-founded Rmoni wireless and has taken the role of CEO to manage and grow the company.

**Ir. Mark Kestens** has a degree in civil engineering at Leuven University (1998). He built a career in software development at various companies, and co-founded Rmoni wireless. Mark has the role of CTO and manages a team of 8 developers, both hardware and software.
<table>
<thead>
<tr>
<th>Participant Number</th>
<th>P07</th>
<th>Participant short name</th>
<th>LT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant full name</td>
<td>Lagassé Technologies</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Short description of the organisation**

LT (Lagassé Technologies) is an industrial telecommunication French company with 30 years experience. It is also a subcontractor for big corporate customers. LT is involved in radio communication technologies, specifically in active-radio-frequency-identification-devices (RFID). The LT company is integrated in the industrialisation centre (the factory is ISO9001, offers complete industrialisation, manufacturing and distribution services through a single point for large high technology electronic devices). The RFID-based communication solutions target security of people and goods, such as Homeland security, valuables in transit, electronic surveillance and healthcare.

The unique shareholder is of Canadian nationality. He is a shareholder of numerous Canadian companies in the field of telecommunications. The collaboration of these companies is strongly favoured in this group of interest. The Canadian partners are Mediatrix, M5T, Gexel, Inmedia and IP5 Corporation. LT has 13 employees and is located in Douarnenez (France).

**Attributed tasks**

LT participates in the MENO project as an industrial partner to offer its expertise on the practical implementation of wireless mesh secured sensor networks. LT is particularly involved in the local sensor nodes. LT will contribute to the definition of future requirements. This will lead to inputs for the overall end-to-end architecture. The network layer will be studied including solutions for data collection and sensor setup. Prototypes for an end-to-end demonstrator will be developed and integrated to validate the designed solutions. LT will disseminate and commercially valorise its results.

**Relevant experience**

LT has a strong expertise in active RFID technology. Due to its history of 30 years in telephony technology, LT has its own development engineers team involved in wireless networks (zigbee, SimplicITI, bluetooth protocol, Tetrapol, Tetra …). LT has also hardware production capabilities with a large business experience since 1972 and in a wide range of different technologies. The company ambition is to develop new own radio products using new protocols.

**Profile of key personnel**

**Alain Perennou** graduated from Ecole Nationale Supérieure des Telecommunications in 1994 (ENST Br) in electromagnetism & antennae. He joined LT since May 1st. He has obtained a Phd, during which he worked the patch antennae mastery and their electromagnetic diagram (many personal publications & international congress URSI papers). The main innovation concerns the mastery of no-planar surfaces antennae and the use of ferri-magnetism substratum. Since 2005 he is in charge of business development in radio communication, radio hand-held and RFID for LC&I and LT (a new & innovative remote control patented, with André Thépaut ENST-Br). He is involved in advanced research activities with local high school & university. Since 1995, he is the NPI (new product introduction) project coordinator of Tetrapol hand-held for Matra Communication, Nortel & EADS Telecom.

**Florian Jegu** joined the company since 2006. He graduated from Télécom Bretagne Ingeniers and is now active as senior Zigbee development engineer.
2.3 Consortium as a whole

The MENO project brings together a diverse and well-balanced consortium with a proven record in the design, development and integration of network communication solutions. The consortium consists of 7 partners and bears a good balance in terms of scientific and technological excellence and skills, in terms of type of organization and in terms of geographical location, as explained in the following paragraphs.

Scientific and technological excellence and skills

The consortium partners have excellent scientific and technological background and possess great skills and expertise in the fields related to the research and development tasks defined in the work packages. In addition, many of the partners have participated successfully in European projects that also targeted design, integration and demonstration. This is summarized in the following table.

<table>
<thead>
<tr>
<th>Partners</th>
<th>Scientific and technological expertise and skills relevant to the project</th>
</tr>
</thead>
</table>
| IBBT     | • Design, development, integration and deployment of secure (using cryptographical solutions) and self-organizing virtual IP networks.  
   • Implementation of Personal Networking solutions using network virtualisation in IST MAGNET and IST MAGNET Beyond  
   • Development of networking protocols (MAC, routing, cross-layer design) for sensor nodes  
   • Design of a modular development framework for the protocol design for sensor nodes  
   • Experience with the deployment of a large-scale Wi-Fi and sensor network test bed  
   • Experience in EU projects, resulting in successful integration and demonstration  
   • Participation in ITEA2 Usenet project on M2M communication, realizing an M2M application scenario |
| JCP-Consult | • Coordinator of and technical partner in several EU projects  
   • Large management experience combined with good technical background  
   • Long experience in technical, administrative and legal aspects of R&D European projects' set up and management |
| VTT      | • Experience on the virtualisation of network connections within the scope of Personal Networks  
   • Research in wireless sensor networks  
   • Expertise in network protocol design and deployment  
   • Expertise with software integration targeting demonstrators and pilot services  
   • Experience in EU projects, resulting in successful integration and demonstration |
| UC       | • Development of middleware for supporting heterogeneous wireless technologies  
   • Research in the coexistence of sensor and high-capable networking technologies and the design of an API to interact with 802.11 and Zigbee sensor networks  
   • Specification, implementation and integration of Personal Networking solutions in IST MAGNET and IST MAGNET Beyond, including the coordination and creation of a testbed  
   • Experience in EU projects, resulting in successful integration and demonstration |
| NEC      | • Experience on sensor data capturing, processing and usage for context-aware applications  
   • Worked on context data management in several EU projects  
   • Large experience in the cloud computing field  
   • Experience in EU projects, resulting in successful integration and demonstration |
• Active in the SENSEI project, a large-scale IP on global-scale sensor networking solutions

RMoni
• Expertise on both hardware and software development for wireless sensor networks
• Implementation of the IEEE 802.15.4 protocol for real-life applications (truck monitoring and warehouses)
• Development of point-to-multipoint network layer
• Implementation of Zigbee 2007 Pro
• Experience in the rollout of sensor networks and knowledge of the market
• Participation in ITEA2 Usenet project on M2M communication
• Active in many interesting markets such as transportation, warehouses...

LT
• Strong expertise in active RFID technology
• Experience with different types of sensors
• Possesses hardware production capabilities
• Active in markets such as transportation, health-care, surveillance...
• Experience with a wide range of different networking technologies

If we map these skills according to their relevance to the different technical objectives of the project (captured in the different technical tasks), we obtain the following table.

Table 6: Partners skills versus objectives

<table>
<thead>
<tr>
<th>Partners</th>
<th>IBBT</th>
<th>JCP-Consult</th>
<th>VTT</th>
<th>UC</th>
<th>NEC</th>
<th>RMoni</th>
<th>LT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecosystem participation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ecosystem management</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virtual network creation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Virtual adapter design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distribution of sensor data</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Naming and discovery</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Application developer API</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cloud services</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensor services</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Application scenarios</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integration and demonstration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Both tables clearly show that the consortium has the necessarily scientific and technological expertise and skills in the right fields, in order to successfully realize the project’s objectives.
**Type of organization**

During the formation of the consortium, great care has been taken to have representatives in the consortium coming from universities, research institutes and industry, including at least one small and medium enterprise. The consortium consists of 1 university (UC), 2 research institutes (IBBT and VTT) and 4 industrial partners (NEC, RMoni Wireless, Lagassé Technologies and JCP-Consult) of which 3 small and medium enterprises (RMoni Wireless, Lagassé Technologies and JCP-Consult) and 1 large company with a long track record in European research (NEC).

Two leading research institutes are included in the MENO consortium. In general, research institutes foster innovation by bridging the gap between fundamental research that is carried out at universities and novel technological developments in industry. In the same sense, research institutes enable companies, authorities and non-profit organisations to join forces within research projects for addressing technical issues. MENO’s purely academic partner is a very active university in EC funded projects, with a technical background and expertise, as well as proven ability to carry out innovative research. Finally, the involvement of industrial partners guards the relevance of the project’s results in terms of valorisation and exploitation. Also, both a large industrial partner as small SMEs are included. Larger industrial partners have in general an impressive track record regarding participation in EU projects, have a large customer base, and as such, have a good vision on the research required to deal with upcoming trends and novel networking technologies. In addition, they have a strong impact on the usage of the project’s results, possibly resulting in a shorter time to market of cutting-edge networking technologies. Finally, the involvement of small SMEs is also beneficial for the consortium. In general, these small, heavily technology focused, enterprises are early adopters of new technologies, exploring new market opportunities. In the longer term, it is in their own interest to be at the first row to be involved in the exploration of novel and innovative technologies in order to stay ahead of the competition. Having them in this project, increases the potential impact of it. The combination of all of these organization types, results in a balanced consortium with a good vision of where technology and networking is heading at and that can bring innovation through cooperation within this research project. In addition, it is well balanced in relation to the project’s objectives, which are promoting novel, innovative networking solutions, while at the same time having applicability in real use cases and wanting to achieve the expected impact.

These characteristics are also reflected in the roles and tasks assigned to the different partners. These are in line with their expertise and impact on the valorisation and exploitation. IBBT and JCP-Consult will take care of the project management. RMoni Wireless has a good knowledge of the market for sensor applications and can provide an excellent guidance in the design of relevant application scenarios and their requirements. Therefore, they will lead WP2. IBBT will lead WP3, based on their strong experience on the design of virtual networks, which is required as a baseline to start building the solutions upon. UC has experience the design of networking protocols and sensor networks and is therefore an ideal candidate to take the lead of WP4. NEC, as a large industrial partner, will lead WP5. They have the expertise on the cloud computing and have a strong experience with projects that require integration. Finally, WP6 will be lead by JCP-Consult due to their strong management skills in EU projects and support for steering the dissemination activities. As such, the responsibilities are nicely spread according to the skills of the different partners. In addition, this assignment has another added value. Industrial partners are taking the lead of the work packages that provide the overall design and application scenarios and that focus on the applications and services that will be integrated into the demonstrator. Since these work packages also have the strongest impact on the further exploitation and valorisation of the results, it is beneficial to have an industrial partner taking the lead, since they have a good view on the market and potential valorisation and exploitation. Academic partners and research partners are strong in research, so it is a straightforward choice to let them have the lead over the work packages that are solely focusing on these innovative research activities.

In numbers, industry effort amounts to 49% of the overall budget, 46% of the funded budget and 49% of the manpower allocation. Research institute’s effort amounts to the 38% of the overall budget, the 41% of the funded budget and 35% of the manpower allocation. Academics’ effort amounts to the 13% of the overall budget, 13% of the funded budget and 16% of the manpower allocation. This information is summarised in the following figures.
The above figures clearly show that the project has achieved a good spread of the overall budget and manpower over the different organization types, with an equal balance between research institutes/academic partners and industry, which is in line with the project’s objectives combining innovative research with practical and industrial relevance.

The MENO consortium is composed of partners from 5 EU countries, namely Belgium, France, Spain, Finland and United Kingdom, providing a good geographical spread across Europe, from North to South.
The balance among these countries in terms of overall and funded budget allocation is depicted in the following figures.

![Figure 10: Budget versus country](image)

**Summary**

Summarized, the complementarity of the partners’ expertise in the relevant fields, their assigned roles and tasks within the project, the involvement of industrial partners to ensure the exploitation of the results, the geographical footprint and the distribution of person months all contribute to the achievement of the project’s objectives.

i) **Sub-contracting:**

The consortium has not identified any issues where subcontracting is required.

JCP-Consult as WP6 task Leader of MENO proposes to subcontract the website design and Hosting. Other mentioned subcontracted budgets are related to CFS (Certificate Financial Statement)).

ii) **Other countries:** N/A

iii) **Additional partners:** N/A
2.4 Resources to be committed

2.4.1 Overall budget

The total effort for MENO reaches 288 man months, for a 30 months project duration. The total project costs overview shows an amount of 3436 k€ while the requested EC funding is 2475 k€.

Table 7: MENO Budget

<table>
<thead>
<tr>
<th>Participant Nr</th>
<th>Organisation, Short Name</th>
<th>Participant</th>
<th>Country</th>
<th>DTS</th>
<th>Demonstration</th>
<th>Training</th>
<th>Coordination</th>
<th>Support</th>
<th>Management</th>
<th>Other</th>
<th>Total</th>
<th>Total receipts</th>
<th>Requested EU contributions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IBBT</td>
<td>BE</td>
<td></td>
<td>683200</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>58000</td>
<td>0</td>
<td>741200</td>
<td>570400</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>JCP-Consult</td>
<td>FR</td>
<td></td>
<td>185480</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>165600</td>
<td>0</td>
<td>351080</td>
<td>304710</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>VTT</td>
<td>FI</td>
<td></td>
<td>571999</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2000</td>
<td>0</td>
<td>573999</td>
<td>431000</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>UC</td>
<td>ES</td>
<td></td>
<td>430560</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>430560</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>NEC</td>
<td>UK</td>
<td></td>
<td>633984</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>633984</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Remons</td>
<td>BE</td>
<td></td>
<td>377600</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>377600</td>
<td>283200</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>LT</td>
<td>FR</td>
<td></td>
<td>328256</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>328256</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>3211079</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>225600</td>
<td>0</td>
<td>3436679</td>
<td>2475414</td>
<td></td>
</tr>
</tbody>
</table>

The strong background competences brought into the project will allow reaching the MENO objectives, with the given budget and time frame.

It is to be noticed that, from the effort (on person-month level) of the project, 6,9 % is used for project management leaving about 93% for the technical activities of the project. 9,4% is dedicated to dissemination of project results (including standardization), showing the strong confidence of the consortium in reaching valuable progress to share with a large community.

A high-level breakdown of this effort, according to the nature of the activity is shown in Figure 11. Here we have made a distinction between efforts focussing on the design and implementation and the efforts focussing on the final integration and demonstration. The largest (about 71%) part of the project is dedicated to the research and development of novel solutions for the creation of the ecosystems, the clean-slate end-to-end protocols and the cloud and sensor services using them.

![Figure 11: Effort breakdown per activity](image)

As this is the key innovation of the project, this relatively large share of the budget is justified.
As presented in section 2.2 and 2.3, the MENO consortium is very well balanced between industrial partners and research institutes in terms of competences. This balance is also ideally reflected in the overall project effort: 141 PM are budgeted for 4 partners in industry (49%), and 147 PM for 3 research institutes (51%).

2.4.2 Other major costs

The resources necessary are committed on a basis to be accessible by all contributing partners that offer their services towards the completion of the MENO project's objectives. Where possible and if required, individual resources will be shared among users exclusively for the completion of the project’s tasks. The major part of funding is focused on project staffing, overhead, travels, computing and network equipment and software tools. Those expenses are presented in Table 8.

<table>
<thead>
<tr>
<th>EXPENSES TYPE</th>
<th>IBBT</th>
<th>JCP</th>
<th>VTT</th>
<th>UC</th>
<th>NEC</th>
<th>Rmoni</th>
<th>LT</th>
<th>TOTAL (K€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel</td>
<td>21</td>
<td>20</td>
<td>15</td>
<td>24.5</td>
<td>40</td>
<td>15</td>
<td>20</td>
<td>155.5</td>
</tr>
<tr>
<td>Subcontracting</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Software licences</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>Sensors-Network Equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>Dissemination</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>TOTAL/PARTNER</td>
<td>23</td>
<td>35</td>
<td>23</td>
<td>34.5</td>
<td>40</td>
<td>15</td>
<td>45</td>
<td>215.5</td>
</tr>
</tbody>
</table>

**Subcontracting**

JCP subcontracting is related to the Website design and hosting during 3 years; the other mentioned subcontracted budgets are related to CFS (financial auditing costs).

**Software licences & Equipment**

- LT: Purchase of a license for embedded development tools (IAR 8051) supporting the design of protocols on embedded devices and a Zigbee radio sniffer. Establishment of a sensor mesh network Zigbee 2007 2.45 Ghz, consisting of 50 nodes equipped with localisation, temperature, movement, acceleration… sensor capabilities (+/- 300 x 50 = 15000€). This network will be made available to the consortium.
- UC: Purchase of the following equipment: PC computer (2 x 2000 € = 4000 €), PDA (3 x 700 € = 2100 €) and sensors and development kit: Cross-bow motes/Sentilla, Zigbee based OEMs and sensor boards (3900 €). The purchased equipment is required by UC to support both the implementation of the proposed solutions, the validation and proof-of-concept demonstration of the end-to-end system. Portable equipment is preferred for the realization of wireless scenarios where end-users will access the sensor-network from their mobile devices.
- VTT: Purchase of the following equipment: sensors and development kit (6000 €). VTT will be involved in the implementation and integration. In that respect, the equipment is needed to support these activities.

**Travel costs**

NEC’s estimation of the travel cost is based on the average of ~15 EU projects from FP7 and from the second half of FP6. It is calculated per person month, which is well suited to reflect the amount of partners’ involvement. Experience shows that this calculation based on real expenses in comparable cases (EU projects in general) appeared to be very realistic, whereas calculations based on an vague list of planned trips often required budget reallocation then during project lifetime.
2.4.3 Mobilisation of the resources

It is worthwhile to say that to reach the objectives set out by the MENO project, the consortium will also mobilise additional resources for the project. In addition to the expertise brought into the project, partners will integrate:

- **IBBT**
  - Will make available a wireless large-scale Wi-Fi and sensor network test bed (+ 200 nodes), allowing the deployment and testing of software components.
  - Will make available existing virtual IP network virtualization software (which will serve as starting point for the network virtualization objectives in MENO), together with a public server infrastructure to make use of this software over the Internet and support on how to use this software and how to design new functionality.
  - Will make available a “virtual wall” emulation environment, allowing rapid deployment and evaluation of complex, distributed systems.
  - Human resources: a PhD student with external funding (scholarship) will contribute to the project.

- **JCP**
  - JCP-Consult will bring R&D expertise acquired in other national projects like Locomotive and Nexttv4all.
  - In addition to the staff funded directly by this proposal it is envisaged that at least one supporting PhD student will be used.
  - JCP-Consult will provide infrastructures and tools for the project partners to better cooperate and communicate.

- **VTT**
  - Hardware resources: A flexible test network for protocol development and prototyping, consisting of Linux-based rack servers (Sun Fire X2100 M2) and network processors (Cavium OCTEON), Ethernet switches, a traffic generator/analyser, and Gigabit Ethernet copper taps.
  - Software resources: Click modular router, tools for traffic monitoring and performance measurements (e.g. OWAMP, D-ITG), and a centralized GUI for controlling the Linux Network Emulation kernel module (NetEm) in several routers.

- **UC**
  - Our existing wireless test bed will support the research to be carried out during the project. This test bed involves heterogeneous wireless technologies and a sensor networks. In addition, UC will bring in its expertise on the creation of experimental test beds in other European projects (e.g. MAGNET Beyond).
  - Human resources: Besides the research funded directly by the project, UC senior permanent staff will collaborate on the project.

- **NEC**
  - Collaborate with Japanese projects on Future Internet as well as on Cloud Computing including staff members from other NEC R&D labs (either Japan, China, or America).
  - Will supervise 2-4 students’ thesis and pay the cost for the students to work at our lab.
  - Will invite researchers involved in the field to colloquium talks in the lab.

- **LT**
  - Will bring in expertise acquired in other national project (Systerminal)
  - Will supervise student work, in-house and at university, about sensor integration in mesh networks
  - Will provide internal validation platform of mesh localisation network, with related support

- **RMoni**
  - Offer existing demo hardware for quick testing
  - Build prototype sensor hardware for integration tests
  - Showcase the MENO project at various national and international shows

Proposal Part B: page [70] of [84]
3 Impact

3.1 Expected impacts listed in the work programme

3.1.1 Expected impact

The work programme lists five expected impacts for the objective ICT-2009.1.1: The Network of the Future. The MENO project will contribute to the following four of them, ranked in order of relevance.

- Wider market opportunities from new classes of applications taking advantage of convergence
- Accelerated uptake of the next generation of network and service infrastructures
- Strengthened positioning of European industry in the field of Future Internet technologies and reinforced European leadership in mobile and wireless broadband systems
- Global standards, interoperability and European IPRs reflecting federated and coherent roadmaps

3.1.1.1 Wider market opportunities from new classes of applications taking advantage of convergence

The next major disruption of the Internet is expected to come with the potential connection of billions of machines and trillions of objects. This Future Internet will form a huge network of interconnected objects, enabling plenty of new services and giving added value to traditional services. Amongst these networked objects, sensor (and actuator) nodes, which have limited capabilities, will take a prevalent place. As a consequence, it will be a great challenge to design architectures that let these devices securely talk to each other and cooperate in a way that suits the applications under consideration. In addition, new challenges related to the processing of the generated data streams will arise.

Today, the importance of these interconnected objects is already witnessed with the advent of machine-to-machine solutions. Gradually, these solutions are moving into all sectors as shown in the following figure.

Figure 12: M2M development by vertical industry (source IDATE 2008)

These solutions are often proprietary and limited to vertical industries. This reveals the need for similar functionalities and exposes the need for convergence and common solutions with horizontal reusable components. Research efforts tackling these issues could represent an immediate impact in this area.

Of course, there are several ways to tackle this challenging problem. Some research efforts target the redesign of the Internet core in order to be able to address the increasing scale of the Internet due to all these interconnected objects and the problems arising with it. Others target the efficient internal design of sensor networks that are interconnected to the Internet via gateways, which in turn are
integrated and managed at a global scale. These different approaches will all impact in a different way how new applications, making use of these interconnected objects, can be realized and deployed.

The MENO project addresses this problem in a unique way by integrating the connected objects that need to communicate and collaborate in a virtual network. Within this virtual network, the most limited devices, i.e. the sensor nodes, can be directly addressed in a natural way and at a local scale, enabling the flexible development of applications. At the same time, the problems related to the data storage and processing are tackled by integrating cloud services into the design. The end result is an integrated end-to-end system offering generic functionality that fits the need of many application scenarios at a local scale and that fits the requirements of many sectors. As such it offers an integrated solution addressing:

- Flexible and secure interconnection of different networked objects, including sensor nodes, independent of their location
- Efficient communication between these networked objects
- Flexible tools for application design and data stream processing and management

As such, the MENO project can have an impact at several levels. Since it offers a generic framework for secure end-to-end communication with sensor nodes, the demonstration of the feasibility of the designed solutions could mean a step forward towards a converged approach. At longer term and depending on the successful outcome of the project, it could become for industries, which adopt the designed solutions, an easier way to get access to different markets.

Further, the proposed end-to-end system can be applied to many scenarios where heterogeneous sensors and actuators are used, enabling a wide range of applications. At the same time, since novel solutions to facilitate the development of applications will be designed, greater flexibility will be offered to application developers for accessing sensor data and efficiently processing it. As such, this increased flexibility for application developers will impact the advent of novel classes of applications, which can in turn lead to new market opportunities.

Next, by integrating cloud functionality in the design, we offer a natural means to efficiently store, process and enrich the sensor data in a scalable manner. This interesting combination can lead to new ways of using and processing sensor data, but can also raise the interest of cloud computing providers to enter these markets and use their cloud resources in a different way than is currently being done.

Finally, the end-to-end system we design is essentially a software solution that is deployed in sensor nodes, computers, cloud resources, etc. Hence, it bypasses the need for dedicated gateways in order to be able to get access to sensor data. As such, the results of this project could stimulate the advent of new players in these markets that develop sensor nodes that are easily usable by end users in an end-to-end manner. Since heterogeneity is allowed, this adoption by end users can trigger new ways how sensors are being used, leading to novel applications and eventually new market opportunities for the involved companies.

3.1.1.2 Accelerated uptake of the next generation of network and service infrastructures

Research targeting the Future Internet can be done in two forms, either taking a clean-slate approach or taking an evolutionary approach. The drawback of clean-slate approaches is that they are disruptive. They redesign the existing architecture completely and as such require very large-scale experimental facilities to evaluate the new design, slowing down the possible uptake of the new solutions. Using an evolutionary approach, incremental patches are applied, thereby moving the system from one state to another.

This project takes a combined approach. First of all, it focuses on a specific problem area of the Future Internet, namely how to make sensor nodes a fundamental part of the Future Internet. Secondly, it focuses on a restricted set of devices that need to collaborate, not on all devices connected to the Internet. Within this setting, the project takes a clean-slate approach by designing novel protocols for communicating with sensor nodes in an end-to-end way, but at the same time, this clean-slate approach is restricted to the involved networked objects by integrating them into a virtual network that can be deployed on top of existing L2 and L3 connectivity (and thus on top of the existing Internet).
So, by developing these clean-slate solutions on top of a virtual network, the developed solutions can be deployed immediately on top of the existing Internet. As such, our approach offers a migration path through virtualisation, while at the same time leaving room for clean-slate research efforts in view of the next-generation network and service infrastructures. Consequently, since the resulting end-to-end system can be deployed over existing technologies and since it is a software solution, it can be easily deployed and used. This accelerates the uptake of the newly designed solutions.

Next to this, the project offers an integrated end-to-end solution implementing a well-chosen set of protocols (including security, connectivity, discovery, API and sensor data processing via cloud resources). Thus, it offers everything that is needed to start building applications and realizing scenarios. In addition, we believe that the end-to-end design of the required functionality within the scope of these virtual networks, opposed to the global scope of the Internet, will more quickly lead to practical and usable solutions. The combination of these features and their natural integration into a single end-to-end system will make the designed solutions attractive, which can mean an accelerated uptake.

Since currently sensor nodes are sold in combination with a dedicated gateway, which is normally not compatible with sensor nodes from different vendors, it is hard for new players to enter the market and to offer new sensor nodes to end consumers. Our approach would avoid this vendor lock-in since we develop end-to-end (software) solutions, eliminating the need for dedicated gateways that process and translate all sensor data. This, in combination with the flexibility to have direct access to sensor nodes and to easily make use of the sensor data or to have it managed by a cloud operator, could attract service providers and accelerate the use of sensor nodes in their solutions adding value to their existing services. Today, this is still a market that is difficult to reach and for which only proprietary and expensive solutions exist. So, our approach can stimulate the uptake of sensor nodes by end consumers as well.

3.1.1.3 Strengthened positioning of European industry in the field of Future Internet technologies

This project tackles a specific aspect of the Future Internet design, namely how to make sensor nodes a full part of the Future Internet and not just an extension. Our approach is different in the sense that it starts from the most restricted end devices and develops complete end-to-end solutions with these restrictions in mind. This approach distinguishes us from other initiatives, but is not disruptive because of the network virtualization we use in these end devices.

As such, if the consortium succeeds in combining their scientific and technological excellence to demonstrate the feasibility of the proposed solutions and showcase a flexible end-to-end system, it would open up possibilities for exploitation and valorisation. In addition, since the proposed solution has a wide applicability and demonstrates its relevance with cloud computing (a very lively research area), it also paves the way for new business opportunities. Raising awareness of this within European industry sector, would strengthen Europe’s position in this particular field related to the Future Internet.

By taking a different approach, we explore new possibilities to bring innovation, which is sometimes needed to advance. A real end-to-end design combining sensor nodes, network virtualization and cloud computing has not been done before. Succeeding to realize this, would bring technological advance. At the same time, industry can learn from this approach and our findings could constitute a useful guide for the Future Internet design on the long term, strengthening Europe’s position in this field.

3.1.1.4 Global standards, interoperability and European IPRs

As stated, we believe that the end-to-end design of the required functionality within the scope of a virtual network, opposed to the global scope of the Internet, will more quickly lead to practical and usable solutions. As such, the focus of this project is on the realisation of an integrated system demonstrating real end-to-end communication with sensor nodes and being applicable to several application scenarios. The project wants to offer a flexible software-based solution, that, when successfully demonstrated, can be deployed at a relatively short time scale.
This is different from an approach that wants to tackle the problem at a global scale and wants to push solutions focussing on specific problem domains into standardization bodies. These approaches lead to the standardization of many individual components and it can take a long time to finally make it into real integrated products that are all interoperable.

Consequently, since this project focuses heavily on an integrated end-to-end system and will only implement a well-chosen set of solutions to realize the application scenarios in mind, the potential impact on standardization is somewhat reduced, since most standardization efforts focus on a particular problem domain. On the other hand, our approach increases the impact related to wider market opportunities and an accelerated uptake. This is a trade-off that needs to be taken into account.

Table 9 gives an overview of some key standard organizations that shape the Future Internet in which sensor nodes will play a role. Also the involvement of MENO partners is mentioned. These organizations try to streamline the sensor related efforts, by describing particular solutions that improve the interoperability of sensor-node-based solutions and their interconnection to the Internet. Mostly, these standardization organizations are focussing on solutions targeted to the sensor network only or are working on the standardization of the gateway functionality. In that respect, MENO is different, since it eliminates the gateway as a device that processes and translates all sensor data.

Although our approach somewhat reduces the potential impact on standardization, it does not at all exclude the possibility of influencing these standardization bodies and making them aware of the project’s novel ideas and solutions. Since our design starts from a different mindset (i.e. eliminating the need of gateways and designing real end-to-end protocols), our research could lead to interesting findings that are worth communicating to these bodies. Also, if the project successfully demonstrates the feasibility of the designed solutions, our clean-slate ideas can have an impact on standardization efforts at the longer term, since they are not in conflict with these efforts. It could eventually lead to efforts, where the functionality of the gateway is reduced, in favour of more end-to-end communication.

<table>
<thead>
<tr>
<th>Group or organization</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>ETSI and ETSI M2M</td>
<td>Recently ETSI launched the Machine-to-Machine (M2M) Technical Committee, aiming to fill a serious gap in today’s standardization of M2M systems and sensor networks (Internet of Things). For example standardization of gateways and API’s are targeted. Since M2M applications are targeted by the MENO project, the findings of the project could be interesting for this group. MENO partner NEC is actively contributing to ETSI M2M. NEC is contributing to the technical specification TS 102 689 on M2M service requirements.</td>
</tr>
<tr>
<td>IETF 6LoWPAN</td>
<td>The IETF 6LoWPAN defined an adaptation layer for IPv6 aimed at sensor and actuator nodes, aiming to reuse already available protocols on sensor nodes and create interoperable networks. Connectivity to the Internet is gateway based. MENO’s approach is different, but its findings related to its end-to-end protocol solutions could provide valuable input.</td>
</tr>
<tr>
<td>IETF ROLL</td>
<td>The IETF Roll group defines solutions for routing over low power and lossy networks. Part of the ecosystems will have these limitations and as such, the project’s findings on addressing and routing solutions could be useful.</td>
</tr>
<tr>
<td>ISA100</td>
<td>The ISA (Instrumentation, Systems and Automation) Society develops a standard to unify wireless automation systems (ISA100.11a). It defines the entire automation system and is based on IEEE 802.15.4 and 6LoWPAN. MENO’s application scenarios also target such systems and its findings could offer interesting lessons for future work.</td>
</tr>
<tr>
<td>Sensor Web Enablement</td>
<td>SWE is an initiative by the Open Geospatial Consortium aiming at the development of a set of standards to enable the discovery, exchange and processing of sensor information (e.g. SensorML). These functionalities are also required by the MENO project and the results of this initiative will be taken into account. In turn, our developments could offer valuable feedback to this initiative.</td>
</tr>
<tr>
<td>IPSO alliance</td>
<td>This alliance is a global non-profit organization trying to establish and promoting IP as the network...</td>
</tr>
</tbody>
</table>
for the connection of Smart Objects. They do not define technologies, but document their use. Raising awareness of the project’s results within this alliance would be an interesting dissemination target.

3GPP
The 3rd Generation Partnership Project (3GPP) is a collaboration between groups of telecommunications associations, to make a globally applicable third generation (3G) mobile phone system specification. Within 3GPP, machine type communications are being looked at. In this area, NEC has led an initial study on M2M and is actively contributing to requirements on machine-type communication (TS 22.368).

OMA
The Open Mobile Alliance is a standards body, which develops open standards for the mobile phone industry. Within OMA, NEC is driving the work on the Next Generation Service Interface (NGSI). Here a context API for retrieving sensor and context information is standardized. MENO’s work on sensor data services and APIs could become relevant.

Next to this, the project’s work can also have an impact on other standardization activities, not directly related to sensors. For example, IBBT participates in the ECMA TC32-PNF group working towards the standardisation of Personal Networks and where virtual (IP) networks play a dominant role. It is clear that on the longer term, the inclusion of sensor nodes in Personal Networks is beneficial for the end users. In that respect, our work in this project, based on virtual network technology, can have an influence on this. NEC participates in the Femto Forum, a not-for-profit membership organisation founded in 2007 to promote femto cell deployment worldwide. This organisation might be including M2M use cases.

Finally, NEC is monitoring the EU mandate 441 on Smart Metering, expecting standardization activities.

3.1.2 Strategy for impact achievement

The foundation for achieving the described impact is laid with the work on this proposal and the consortium. The proposal targets an end-to-end system having to offer very specific functionality. This in turn has been broken down into clear objectives, which have also been reflected in the work package and task break down (WP2-5), a solid management (WP1) and dissemination plan (WP6). Next to this, several partners in the consortium have a solid basis on network virtualization and have, in the past, managed to design and integrate end-to-end solutions.

As such, by having a clear work plan strategy and strong expertise in research, integration and demonstration, the project shall succeed in reaching its objectives and shall come up with an end-to-end demonstrator. Demonstrating the feasibility of the proposed solutions and showcasing a flexible end-to-end system can be seen as the most important strategy for impact achievement. It will lead to exploitation and valorisation plans, will raise interest with industry and standardization organisations and will bring findings in a credible way to a broader European audience. This in turn contributes to the expected impact as described in the previous sections.

3.1.3 European dimension

The principal benefit of carrying out the research at the European level is that it enables a consortium of players that combine the technical skills required to undertake MENO objectives with the industrial leadership necessary to ensure commercial exploitation of the results. The successful achievement of the project’s objectives and the expected impact is only possible through a European project with the current size and composition and is not possible at a national level only.

First of all, no single research institute or organisation has all scientific and technological expertise for designing a new end-to-end system, covering everything from connectivity up to services. As such both academic partners and industry are needed in order to do research that is in line with industrial expectations. This is crucial when designing an end-to-end system that must fit the needs of real use cases. In addition, different backgrounds and views only stimulate discussion during design and stimulate innovation.
Further, having a consortium consisting of several partners from different countries definitely has a larger impact and higher credibility. Dissemination can be done at a much larger scale, addressing a much broader audience, which is crucial achieving the expected impact.

3.1.4 Other relevant European or National funded research

The MENO project builds on the results from other European and international research and development initiatives in the field of virtual networks, sensor protocol design and cloud computing. This is strengthened by the experience of partners in these domains through national funded research. This relevant European or national research covers a wide range of projects, both finished and ongoing, as well as output from other academic and industrial research and development. An overview of these relevant projects has been given in the section on related work and overview of the state-of-the-art (section 1.2).

3.1.5 Influence of external factors

The expected impact of the MENO project will be achieved under several assumptions and as such, is influenced by several factors.

Most importantly, there is the acceptance of the new design approach we propose: including sensor nodes and cloud resources in virtual networks and eliminating the need for gateways through clean-slate end-to-end protocols. This approach is not fully inline with today’s efforts related to the communication with sensor nodes. Today there is a strong dominance of the gateway-based approaches, reflected by current standardization efforts and the consortium should have a strong case for promoting their solution. As such, this acceptance can only be created by successfully demonstrating the feasibility and advantages of the designed solution and is as such dependant on the quality of the project output and the internal progress and management of the project. To this end, we will make several provisions to achieve this goal: study of state-of-the-art before and during the project, establishment of a correct and realistic work plan, use of partners’ channels towards industry, dissemination to a broad audience, follow-up of upcoming standards, etc.

3.2 Dissemination and/or exploitation of project results, and management of intellectual property

3.2.1 Exploitation and dissemination plan for use of project results

3.2.1.1 General consortium exploitation and dissemination plan

The main focus of the MENO project is the successful realization of an integrated end-to-end system combining network virtualization, sensor nodes, clean-slate end-to-end protocols. Working in an efficient and open way towards this goal and achieving it, will enable the project partners to

- Disseminate these results to a broad audience of both industry and academic people
- Establish concrete exploitation plans for further deployment of the results
- Setup follow-up projects at European and national level
- Establish links with industry or other research projects that would benefit from the developed solutions and promote the designed solutions
- Influence with its clean-slate solutions the Future Internet design
- Let clean-slate ideas float into standardisation bodies and sensor/M2M initiatives

In order to achieve these dissemination and exploitation goals, the project will take the following actions and measures (see also WP6):

- Produce a Plan For Dissemination quickly after the kick-off, including plans for publications and scientific articles, as well as other means as described below. The main journals targeted for publications are IEEE Sensors, International Journal of Distributed Sensor Networks, Ad Hoc Networks, Sensor and Actuators

Proposal Part B: page [76] of [84]
• Maintain an overview of relevant national and international conferences, exhibitions and events and promote inside the consortium an active participation to related workshops and conferences, and for journals publication. The main targeted events that have been identified are IEEE Sensors, IEEE SECON, SENSORCOMM, ICT Mobile Summit, ACM SENSYS.

• Maintain an overview of the clustering, technology platforms and concertation events of the European Commission since it is an opportunity for getting our results to be accepted by a broader audience in other FP7 project.

• Contribute to European Technology Platforms: Technology platform which is particularly targeted is EPOSS (via VTT), but also eMobility and NESSI (via IBBT, NEC, JCP).

• Contribute to cross-ETP strategic research agenda and vision. Provided that this initiative continues, the project will contribute with its vision and roadmap on these 2 documents.

• Participate to the Future Internet Assembly: MENO objectives are particularly suited to the FIA, as they address several areas like cloud computing, networking, internet of things, security; therefore the project intends to contribute to the corresponding working groups already in place.

• Offer a “communication kit” that can be used to disseminate the project concept, objectives and intermediate results.

• Setup and maintain an attractive project website with up-to-date information about the project's progress and results. The website will be actively used as an information and exchange platform.

• Organisation of a project workshop: the initial idea is to organise a workshop between several projects and initiatives on the same area, with the objective to present the project results, and exchange with the view of other projects/stakeholders. The workshop will be organised either together with concertation meetings, or during Mobile Summit 2012 (M24 of the project). Also the project will seek maximum collaboration with larger IPs like SENSEI (and successors) for event organisation.

• Setup collaboration with projects in the Asian-Pacific and North American region working on the Future Internet, M2M, as well as Cloud Computing.

• Set-up active collaboration with other projects and initiatives: several projects among the list set in section 1.2 are already identified like:
  o SENSEI: on interconnecting distributed sensor nodes and the design of sensor node protocols (in SENSEI: restricted to the sensor islands, in MENO: end-to-end). NEC is a partner in SENSEI.
  o 4WARD: identification whether clean-slate MENO solutions could be compatible with the Future Internet virtualization functionality targeted by 4WARD.
  o AWISSENET: on security across sensor networks (in AWISSENET: in PANs and sensor networks, in MENO: as part of the virtual network that includes sensors).

• Participate in standardisation bodies with objective of concrete project contributions: as mentioned in section 3.1.1.4 a number of standardisation bodies where partners are already active can be appropriate for project contributions, more particularly the following bodies will be addressed in priority:
  o ETSI M2M will be approached by NEC, IBBT and JCP at the start of the project to understand what contribution can be made; initial targeted contribution is on the architecture, derived from D2.1, D2.2 and D2.5. NEC is already actively contributing to ETSI M2M.
  o OMA: NEC is active in OMA, standardizing a context API for retrieving sensor and context information. Findings from MENO on data services and APIs could constitute a useful contribution.
  o 3GPP: NEC participates in 3GPP. NEC has led an initial study on M2M and is actively contributing to requirements on machine-type communication (TS 22.368).
  o ECMA TC32-PNF: IBBT participates in ECMA TC32-PNF, focussing on the specification of Personal Networks, using network virtualization. The architecture
designed in the project could possibly result in a specific contribution to more focussed design documents that will be written.

In addition, the project management will (see also WP1)

- Monitor the overall progress and achievement of the objectives
- Assess the quality of the delivered work
- Coordinate and ensure effective communication between the partners
- Maximize the potential for exploiting results

Through these measures, individual partners and the consortium as a whole will be able to maximize their dissemination and exploitation results. In the following section, the more detailed plans of the individual partners are described.

3.2.1.2 Individual partner exploitation and dissemination plans

**IBBT**

IBBT has an extensive experience with the design of virtual IP-based networks, which has resulted already in field trials with real end users in the scope of a national project, and of which the valorisation potential is being further studied. IBBT plans to use the results obtained within the MENO project for further enhancement of its knowledge and competence in this field and in the field of sensor networking.

This knowledge can then be used for transferring it to industrial partners for further commercialisation of the results, which is one of the roles of IBBT as an independent research institute. Next to this, IBBT also enables the valorisation of research results, possibly in cooperation with industry, through initiatives such as the IBBT iBoot camp. This IBBT iBoot camp is a highly focused approach to turn research knowledge, ideas and business opportunities into viable and executable business plans.

Further, the enhanced knowledge and competence obtained through the participation in the MENO project will be exploited and used for participating in new projects and setting up partnerships in other projects, both in the academic and (national and European) industry world. The scientific results will also be disseminated through publications both in journals and at major conferences. They will also impact on the education, because the research is performed at the Department of Information Technology (INTEC) of the Ghent University, where INTEC is responsible for Bachelor and Master courses on telecommunication networks. IBBT further aims at exploiting the project results through the training of highly qualified engineers in PhD programmes.

**NEC**

NEC’s long-term vision is “using the power of innovation to build an information society friendly to humans and the earth”. As a major IT/Network vendor, the vision of sensors or low-power devices as a cornerstone of the Future internet will bring major new business opportunities, especially in the following areas:

NEC sees Cloud computing and Cloud services as a major new business area strengthening its portfolio of products for the Next Generation Networks (NGN) and the Future Internet. Including the ubiquitous environment into delivering services will open IT and Network systems to new opportunities. There is currently a shift from traditional IT systems towards service and cloud-oriented systems. MENO will develop core technologies enabling to include massive sensor information into cloud services. Especially the network virtualization techniques as well as the methods for sensor data processing using cloud resources are very promising.

NEC customers are demanding an advanced mobile/wired service platform and new services on top. The project results will enable to create these services, not only for mobile users, but also for the Digital Home, for Enterprises, and for Public Spaces.

The NEC Laboratories Europe (NLE) is driving R&D towards the Future Internet, Next Generation Networking, and Next Generation Service Platforms. As an established player in the European R&D community, NLE will work in MENO to advance research and technologies for sensor networking. We expect from MENO high-quality research contributions, IPR, and a new approach for integrating
sensors with cloud computing. We will bring the results of MENO to industry fora and standardisation where applicable.

**VTT**

As a contract research organisation, VTT seeks to create a wide range of technology and provide applied research services, so to actively enhance the competitiveness of industry and other business sectors. By contributing to MENO solutions, VTT will further improve its expertise in the field of telecommunication networks in general and sensor networking, network virtualisation, and zero-configuration operation, in special. The enhanced knowledge and competence obtained through participation in the MENO project will be exploited for setting up new projects with national and European partners, both in the academic and industrial world. VTT aims at transferring the knowledge built in the MENO project to industrial partners, like sensor network manufactures and system developers, cloud computing platform operators, M2M communication providers / manufactures and also telecom operators, for further development and commercialisation of the results.

**UC**

University of Cantabria (UC) has a long experience on the design and implementation of middleware components aiming at virtualizing the underlying technologies so that upper levels can be isolated from physical deployments. The work in MENO will be used to carry on with UC’s research agenda following the experimentally driven innovation approach. Additionally, the UC will publish and disseminate its findings in the involved technical activities in the various international conferences, learned journals, and popular magazines. The University will also participate in organising the necessary workshops.

The UC being a higher education institute will use the research experience gained during their involvement in MENO for advancement of training and education and further research in the field. The lessons learnt from this project will be used to enhance the lecture materials for both undergraduate and postgraduate courses (delivered to a wide spectrum of international and home students). This will help in reshaping the design approach for the future researchers and designers of the communication systems. Also the gained knowledge will be used in identifying new research challenges for the future and ongoing MSc and PhD projects.

Knowledge acquired in MENO will be used also to identify new collaboration paths with the industry in order to stimulate the deployment of technologies and services around the Internet of the Things concept. In this sense, having a real world deployment will be extremely useful for attracting companies and entrepreneurs since it will ease the task of showing the applicability of UC knowledge. UC will continue with its tradition of tight collaboration with the industry in order to really impact the market at medium term by the lessons learned in such a project.

**RMONI**

RMONI has been an early adaptor of the IEEE 802.15.4 and Zigbee technology, building commercial Wireless Sensor Networks as of 2005. This has resulted in a product called ‘sensor2web’, which is wireless –hence easy to install- and webbased –hence easy to use. In the early days, RMONI has put a lot of effort in market exploration, and in finding and convincing the early customers: ‘wireless is reliable and suitable for your application…’. This has resulted in an image as ‘the wireless sensor experts’, with the first proven product range on the market. Along the way, other and bigger players have emerged in the same playing field, so it is key for RMONI to stay ahead of this new competition. For this reason we participate in research projects such as ITEA Usenet, so –even being an SME- we are at the first row when and where the technological future is being prepared.

Our plan is to disseminate by valorisation of the project results. The expertise (and funding) of this project will allow us to experiment with new innovative sensor technologies, and help us build our long term roadmaps. Our expectations are that this project will help us to stand out –once again- as an SME, and maintain our position as a technologic forerunner in the WSN area.

Finally, our experience from comparable national and international projects, is that the contacts and networking that arises from the collaboration with universities and large companies is a big added value for an SME like RMONI.
JCP-Consult

JCP-Consult has a strong activity of technical training on advanced technologies like new coding schemes and advanced architecture. JCP-Consult will therefore target to provide advanced training courses to the industry with the results of the MENO project.

A part of JCP-Consult’s activity is the development and distribution of high-tech M2M products. With its technical involvement in the project MENO, JCP-Consult wants to extend and improve its M2M products to the mobile world.

Lagassé Technologies

LT is IEEE802.15.4 adaptor of mesh Zigbee technology. LT is also involved in many other active-RFID protocols equipped of sensors. Dissemination of the project results and valorisation is the objective of LT. The expertise (and funding) of this project will allow us to experiment with new radio protocol, and to help us building our long term roadmaps.

Finally, LT’s collaboration experiences with companies and academic partners is a big added value for an SME. Knowledge acquired in MENO will also be used to stimulate the deployment of technologies and services around LBS market (location based services) around physical measurement combined with the Internet things concept. The enhanced knowledge and competence obtained through participation in the MENO project will definitively help the company to achieve this goal.

3.2.2 Management of knowledge and intellectual property

The project will start from existing background on network virtualisation and will extend this to integrate sensor nodes and cloud resources and to create an interface to allow a clean-slate design on top of it. Further, partners will bring in background expertise on sensor network protocol design and cloud computing. As such, it is important within a collaborative project to manage the intellectual property rights of partners bringing in their own technological, scientific and market background that is needed to successfully fulfil the project’s objectives. Settling these issues in a way that is agreed upon by all partners is obligatory to guarantee a smooth and unobstructed collaboration between the partners. It is also of importance to all partners that want to further exploit the project’s results.

At this time of the project proposal, with close references to The Annex II – General Conditions of the Grant Agreement, some general guidelines have been discussed and agreed between partners. All the basic principles of background, foreground and access rights as well as the rules for protecting them will be clearly presented in the Consortium Agreement that will be finalised before the project starts.

FP7 has pointed out two main objectives in the Management of Foreground:

- To make the foreground that a project produces available to the public
- To ensure that this foreground of the beneficiary is adequately protected by intellectual property rights

To this end, the project management Committee will create, from the very beginning of the project, a project reference manual (see WP1 – task 1.1 – D1.1) that will incorporate all rules and guidelines concerning the management of this IPR, both background and foreground. This will result in a plan to handle this. Next to this, a more detailed knowledge management guide will be created (see WP1 – task 1.1 – D1.3) dealing with all these rules and guidelines. Finally, in order to smoothly implement the IPR provisions, a special session covering IPR issues will be organised in the kick-off meeting.

In practice, during the project life, a session in IPR management will be organised at each general Assembly meeting, to ensure the objectives settled here above:

- To identify potential background issues
- To follow-up the foreground use, i.e. patent application by each partner, and foreground made available to the public
- To identify and arbitrate potential issues of joint foreground creation, especially between academic and industrial partners
Furthermore, once a problem occurs, a special session on IPR can be organised at each project meeting. One contact person per partner will be identify as dealing with IPR issues in the project. The IPR matters will be managed directly by the coordinator, with assistance of the legal council.

The basis of the management of the IPR will be set up as follows, respecting the principle of IPCA Consortium Agreement

**Foreground**

**Use**
The participants should use the foreground that they own, or ensure that it is used. During the project, the partners will manage the foreground as it is produced and investigate the best exploitation routes. To this end, the consortium will submit a “Plan for the Use and the Dissemination of Foreground” and will undertake the envisaged exploitation routes.

**Ownership**
Foreground resulting from the project is owned by the participant generating it. When foreground is generated jointly (i.e. where the separate parts of some result cannot be attributed to different participants), it will be jointly owned, unless the participants concerned agree on a different solution. In that case, each of the joint owners shall be entitled to use their jointly owned foreground on a royalty-free basis, and without requiring the prior consent of the other joint owner(s), and each of the joint owners shall be entitled to grant non-exclusive licenses to third parties, without any right to sub-license, subject to the following conditions:

- At least 45 days prior notice must be given to the other joint owner(s)
- Fair and reasonable compensation must be provided to the other joint owner(s).

**Protection**
Valuable Foreground will be protected by its owner(s) through filling of patent application where possible, or other IPR protection measures. The Parties undertake not to left valuable foreground unprotected. More specially, all the intermediate results that constitute valuable foreground and that are eligible to IPR protection will also be protected as soon as possible by its owner(s). No dissemination of Foreground will take place before a decision is made regarding its possible protection.

**Background**
Each Party shall remain the owner of its own background.

**Access Rights**
Access rights to another participant's foreground or background will be defined in the Consortium Agreement.

Moreover, it has also been agreed that all partners will be requested to fill the register of background in order to be added in the Consortium Agreement. Any particular pieces of background that will be excluded from access rights to other participants will be explicitly stated at this stage.
## 4 Ethical Issues

Table 10: Ethical Issues table

<table>
<thead>
<tr>
<th>Informed Consent</th>
<th>YES</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the proposal involve children?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the proposal involve patients or persons not able to give consent?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the proposal involve adult healthy volunteers?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the proposal involve Human Genetic Material?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the proposal involve Human biological samples?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the proposal involve Human data collection?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research on Human embryo/foetus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the proposal involve Human Embryos?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the proposal involve Human Foetal Tissue / Cells?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the proposal involve Human Embryonic Stem Cells?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Privacy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the proposal involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the proposal involve tracking the location or observation of people?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research on Animals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the proposal involve research on animals?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are those animals transgenic small laboratory animals?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are those animals transgenic farm animals?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are those animals cloned farm animals?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are those animals non-human primates?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research Involving Developing Countries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use of local resources (genetic, animal, plant etc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benefit to local community (capacity building i.e. access to healthcare, education etc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dual Use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research having direct military application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research having the potential for terrorist abuse</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICT Implants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the proposal involve clinical trials of ICT implants?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL

X
5 References

This section provides an overview of all references in section 1.2, following the sub-section structure.

Today’s communication between sensor nodes and IP devices


Network virtualization


[4WARD] The FP7 4WARD project, http://www.4ward-project.eu/


Proposal Part B: page [83] of [84]
FP7-ICT-2009-5 MENO – STREP proposal


Cloud computing


[Reservoir] FP7 IST RESERVOIR, “Resources and Services Virtualization without Barriers”, http://www.reservoir-fp7.eu


Development frameworks


[TinyKeyMan] http://discovery.csc.ncsu.edu/software/TinyKeyMan/index.html

[TinySec] http://www.cf.cl.cam.ac.uk/research/security/sensormets/tinysec/

[Heinzelman04] Wendi B. Heinzelman; Amy L. Murphy; Hervaldio S. Carvalho and Mark A. Perillo. “Middleware to support sensor network applications”, IEEE Network vol 18, 2004


Relevant Future Internet activities and projects


[4WARD3] FP7 IST 4WARD project, D2.1 Technical Requirements


Demonstration

[PANLAB] Pan European Laboratory Infrastructure Implementation, http://www.panlab.net