Glocal enterprise network focusing on customer-centric collaboration

D6.2
Implementation of the pilot demonstrators

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| Main Contributors | CAS (lead partner) - Adrián Juan-Verdejo, Holger Bår  
PLON - Carlos Valencia  
Prolon - Thomas Maltesen |
| Other Contributors |
| Internal Review | UNINOVA - Luis M. Camarinha-Matos  
UvA - Hamideh Afsarmanesh |
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Deliverable summary

Within the context of the validation of the whole GloNet ecosystem and the proposed models, concepts, and tools, this deliverable shows the development of the functional GloNet system. Furthermore, we show the integration of the different parts of the GloNet System and its integration with the pilot demonstrators. We describe how we integrated both pilot demonstrators—the solar plant and the building automation—with the GloNet system with the main focus on the solar plant.

The system integration brings together the various sub-systems utilizing a variety of techniques such as computer networking, application integration, and business process management. This is a report providing a short system overview together with screenshots of the relevant services related to each pilot demonstrator. The report also explains the interoperability requirements of the pilot demonstrators and the implementation of both pilots.

Additionally, the report explains some concepts related to the GloNet System integration, from the common data model description to the newly implemented GloNet dashboard, including the GloNet synchronisation framework.
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PROJECT-RELATED SUMMARY

This deliverable is a result of the work done in WP6 Experimentation and Pilot Development with the aim of validating the GloNet system and the scientific and technical contributions of the GloNet project. Aiming at validating the GloNet system and its specific innovative services, WP6 supplies the necessary open technical infrastructure and services. The system integration captures the capabilities provided through the interaction between the various services. The GloNet project organises WP6 in three consecutive tasks to integrate the disparate subsystems within the GloNet system and to implement the pilot demonstrators:

- Task 6.1 — *GloNet sub-systems integration*
- Task 6.2 — *Pilot design and implementation*
- Task 6.3 — *Measurements and technical validation of results*

This deliverable summarises the integration results in the context of Task 6.1 — *GloNet sub-systems integration* aiming at linking software services—hence applications—within the cloud-based GloNet platform. This deliverable specifies the pilot demonstrator of the building automation case and shows the development and implementation of the two pilot demonstrators in the GloNet system. Further deliverables will describe the metrics explained in WP1 to validate the results according to task 6.3, *Measurements and technical validation of results*. 

![Figure 1: Work package 6 plan](image)

WP6 - WP6 - Experimentation and pilot development

- 6.1 GloNet sub-systems integration
- 6.2 Pilots design and implementation
- 6.3 Measurements and validation of results

Jan 13 | Jan 14 | June 13 | Dec 13 | Mar 14 | Sep 14 | Jan 15
---|---|---|---|---|---|---
50 | 51 | 52 | 53 | 54 | 55 | 56
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37 | 38 | 39 | 40 | 41 | 42 | 43

.4
1 INTRODUCTION

The GloNet models, concepts, and systems offer an agile environment for networks of SMEs striving to provide service-enhanced products. With the association of services to manufactured products, GloNet creates value and differentiates the products a VO provides. With product differentiation, new business opportunities appear. Organisations associate these services to their complex, highly customized and long-life products to add value to them. Examples of such complex products are solar energy plants and building automation projects. In this deliverable, we focus in these two examples to show the GloNet models, concepts, and functionalities and how to apply all of it to actual use cases. In both cases, we focus on a long life-cycle product with interesting opportunities to introduce new services and particularly new forms of service delivery through collaboration. Additionally, similar cases exist in other sectors.

We set here the ground to validate the GloNet system and the scientific and technical contributions of the GloNet project. We firstly show the system integration we did before the actual implementation of the pilot demonstrators. The system integration focuses on the relevant tasks to make the whole system work seamlessly with the different components that compose it. We harmonised the data models of the GloNet sub-systems such as the PST and the VO formation functionality and improved the synchronisation framework to accomplish this. Additionally, we show the functionalities to summarise important information such as the portfolio repository and provide a general overview of the pilot demonstrators.

Once we integrated the whole system, the end users specified their use cases in the GloNet system. Firstly, the end users thoroughly defined the whole scenario. Then, we identified the key business scenarios of the end users and they specified and implemented the pilot demonstrators. We used this methodology for both cases the solar plant and the building automation cases.

1.1 Detail specification of the pilot demonstrators

D6.2 describes the detail specification of the pilot demonstrator for the solar plant case whereas Section 3.2.1 specifies the pilot demonstrator for the building automation case.

iPLON is a small and medium enterprise (SME) with a global view to expand its activity to an emerging market to overcome the challenges of the current economic crisis and collaborated with local stakeholders. Therefore, a good example of a glocal enterprise. It also illustrates the case of a European SME expanding its activity to an emerging market as a way to overcome the challenges of the current economic crisis. The Charanka solar plant moves from traditional sub-contracting practices to the establishment of collaborative networks and partially remote service provision. Both changes entail organizational changes as well as some changes affecting the business culture and practice: implementation of collaborative principles and training provision. The Charanka solar plant and its associated services provision constitute a socio-technical system. The mapping of the solar plant to the GloNet principles affects the technological and organizational structures as well as the interactions between people and technology.

In order to implement all these changes, the affected end users learnt about the GloNet conceptual framework throughout the duration of the project through technical discussions between the developers and the end users. The end users identified and modelled the collaborative organizational forms to then design the operating principles and adjust them to the new organizational structures. The end users assessed the effects of the adoption of new structures for service provision and identified weaknesses. In response to those weaknesses, the end users communicated with their partners as they instantiate the GloNet system for their particular Charanka solar plant case. Further, they arranged with their partners training sessions for other system operators and users
1.2 The setup of the implementation of the pilot demonstrators

The responsible parties of each of the pilot demonstrators started the implementation with the out-of-the-box implementation of the GloNet system and reported their new requirements. Because of the execution of the phase of the GloNet project related to the implementation of the pilot demonstrators, new requirements emerged. PROLON and iPLON documented them by using the tools the development parties of the consortium had in place during the development process of the whole GloNet project.

1.2.1 Development teams

We had three development teams to address the emerging requirements on an agile manner so that delays in the development process would not harm the pilot demonstrators: CAS and Komix, UNINOVA, and UVA. In order to increase the communication levels of the remotely located teams and the two users we employed the JIRA software tool for project management and bug and issue tracking.

The remotely located development teams synchronised and exchanged ideas, tips, and results with the other parties through the transparent reporting of their activities in JIRA related to the issues or bugs detected by the end users. The end users were in charge of assigning the issues or bugs to the relevant development team together with a thorough description as for to facilitate reproducing the situation. Figure 2 shows the ten projects created together with the responsible person of taking care of the incoming issues and bugs.

<table>
<thead>
<tr>
<th>Project</th>
<th>Key</th>
<th>Project Lead</th>
</tr>
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<tbody>
<tr>
<td>Collaboration Spaces</td>
<td>CS</td>
<td>Adrian</td>
</tr>
<tr>
<td>E-Notary</td>
<td>EN</td>
<td>Adrian</td>
</tr>
<tr>
<td>GloNet Platform</td>
<td>GP</td>
<td>Adrian</td>
</tr>
<tr>
<td>Product Portfolio</td>
<td>PP</td>
<td>Adrian</td>
</tr>
<tr>
<td>Product SpecificationTool</td>
<td>PROD</td>
<td>Mohammad Shafahi</td>
</tr>
<tr>
<td>Value Align System</td>
<td>VAS</td>
<td>Ana Inês Oliveira</td>
</tr>
<tr>
<td>VO Formation Context</td>
<td>VFC</td>
<td>Ana Inês Oliveira</td>
</tr>
<tr>
<td>VO Negotiation Support</td>
<td>VNS</td>
<td>Ana Inês Oliveira</td>
</tr>
<tr>
<td>Workflow</td>
<td>WORKFLOW</td>
<td>Adrian</td>
</tr>
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Figure 2: Development projects for the pilot demonstrators

To facilitate the timely fulfilment of the implementation of the requirements and at the same time make the implementation effort coherent with the efforts of the development organisation in other projects each development organisation created a board for their main responsibilities regarding the development of the implementation of the pilots. Nevertheless, collaboration and cross-pollination of ideas and developers happened for those cases when multiple development teams had to collaborate to fulfill the requirements. Figure 3 shows the scrum board to organise into subsequent two-weeks sprints the backlog of tasks directly assigned to CAS and Komix.
1.2.2 Pilot demonstrator implementation teams

iPLON used the specification done in the previous D6.1 deliverable to instantiate the conceptual framework and implemented the key business scenarios in the GloNet system. As for PROLON, besides these two activities, PROLON specified the pilot demonstrator for the building automation case.

iPLON had a distributed team in Germany and India for the implementation of its pilot demonstrator. They organised several meetings with the members of the VBE to gather all the required data to enter on the GloNet system regarding their profiles and competences. Furthermore, iPLON mapped those VBE members to their roles within the pilot demonstrator and identified the different organisational forms. Once they did this, they moved into the implementation of the key business scenarios to realise some of the new requirements derived from the implementation phase. Because they created new tasks and issues as the one in Figure 5.
The same process applies for the building automation case that PROLON implemented.

1.2.3 Quality assurance mechanisms

The software quality assurance was ensured at the development teams with many and varied methods conforming to the CMMI model. The entire software development process included requirements that the end users defined with JIRA, in-house software design, coding and SVN-based code control. Furthermore, the development parties executing unit test activities before each of the integration tests prior to the commit to the main branch in the SVN repository and further deployment to the GloNet servers. In further steps, the end users performed acceptance testing. With all these methods in place, the consortium ensured achieving its goals by means of performing measurements and verifications.
2 GLONET SYSTEM INTEGRATION

2.1 GloNet synchronisation framework

The cloud-based GloNet platform includes the GloNet synchronisation framework to enable synchronising the data with external systems or the different GloNet sub-systems. The synchronisation of data happens within individual records as well as the relations between them. The framework only tracks the state of records and their relations to increase its efficiency due to transferring the changed data. At the beginning of a synchronisation session, the framework obtains the state from each of the two synchronised systems and compares them with the known state of the last session. Figure 6 shows a high-level description of the philosophy of the implemented synchronisation framework.

![Figure 6: GloNet synchronisation framework philosophy](image)

2.1.1 The architecture of the GloNet synchronisation framework on a bird's-eye view level

Figure 7 shows the architecture on a bird's-eye view level emphasising the synchronisation mechanisms in play between two systems (System A and System B). The ConnectionBridge module controls the communication between the sync framework and the synchronised system. The Sync Framework manages the workflow of the entire synchronisation session and manages the communication with the SyncDAO and the ConnectionBridges. The SyncDAO contains information about the synchronisation for each system.

![Figure 7: Bird's-eye view of the architecture around the synchronisation framework](image)

2.2 Common data model description

The GloNet system uses the synchronisation framework of the cloud-based GloNet platform to synchronise the data that the different GloNet systems and sub-systems share. The framework synchronises the data linked in the different sub-systems so that the GloNet system does not have independent data silos but works as an integrated approach to help the different VOs collaborate and...
provide service-enhanced products. The synchronisation framework harmonises the meta-data of the sub-systems and allows seamless data exchange and synchronisation with the meta-model of the complete GloNet system. GloNet lets its users model an integrated exploitable product whose business processes work across the different sub-systems. Additionally, the common data model allows mapping data objects from legacy systems such as an external sensorial system coming from an end user such as iPLON.

The cloud-based GloNet platform offers an abstract data model, namely the meta-model for the complete GloNet system as Figure 8 shows. Each of the GloNet sub-systems can implement a part of this global data model tailored to its specific data model. The synchronisation framework links the common parts of the concrete data models. That is, the synchronisation framework links the concrete data models in those parts where they intersect. As a result, the synchronisation framework integrates the various sub-system of the GloNet system such as—among others—the VBE management system, the VO negotiation and VO formation sub-systems, and the PST. The synchronisation framework maintains the data structures that the GloNet sub-systems share. Furthermore, the synchronisation framework assists the integration of legacy systems such as the systems that iPLON was using before the implementation of their pilot demonstrator, for example the soiling loss measuring system.

2.3 Single-sign-on

The GloNet sub-systems have fully incorporated the single-sign-on to integrate all the sub-systems and enforce the seamless and transparent collaboration. We used the Open ID mechanism for decentralised authentication and identity management.
2.4 GloNet dashboard

The portfolio repository uses the cloud-based GloNet platform with the aim of supplying a sort of dashboard encompassing all information related to the entire lifecycle of the product linked by the portfolio. The portfolio functionality receives complex products defined in the PSS (Product/Service Specification) sub-system that consists of the PST and the SST (Service Specification Tool).

Additionally, the GloNet portfolio repository offers the possibility to export the complex relations that we have explained to a comma separated value file so that the user can use this data for other purposes and after porting these data.

The GloNet consortium developed the portfolio repository to list the portfolios interesting for the user so that she can check per portfolio a summary of the information linking the complex products or services and the VOs involved in the provision of them. The GloNet portfolio functionality is a single access point to all the relevant information of the service-enhanced products that the members of a network offer. The GloNet portfolio functionality includes the product specification, the specification of the business services associated to a product, the model of the implemented product, historic data collected during product's usage and operation, the VOs involved in the product life cycle.

The portfolio repository enhances the efficient management of the relevant information on complex products and service-enhancement so that other sub-systems and services can re-use the information along the product life cycle.

Figure 9 shows the GloNet portfolio functionality for a specific complex product—the Charanka solar plant in this case—after the VBE/VO member—iPLON in this case—creates it. iPLON defined the solar plant complex product with the PST and then launched it so that the GloNet portfolio functionality created the portfolio for the solar plant complex product. On the right-hand side of Figure 9, this portfolio includes a tree with the summary of the most important information related to the specification instance. The tree includes the sub-products linked inside the portfolio repository for the specification of the Charanka solar plant complex product. iPLON assigned the appropriate users, roles, and permissions for the portfolio. The GloNet portfolio repository keeps track of every change on the portfolio. Figure 9 highlights with a red circle the button to export the information contained in the product portfolio to enhance sharing a document with a summary of the contained information.

Figure 9: The GloNet portfolio functionality accessed through the portfolio repository
2.5 GloNet Workflow Management System

The current market offers dozens of, some of them matured, workflow systems such as MS Dynamics, Comindware Tracker, ADONIS, Workflowgen, Imixx, jBPM (JBoss), and Activitiy (Open source). Following our approach as the GloNet consortium, we developed a new workflow management system to support the tight integration with the overall GloNet system as we explained with more detail in D3.4 [Fehler! Verweisquelle konnte nicht gefunden werden.]. The GloNet Workflow Management System as a research prototype cannot compete in terms of reliability or functionality at the same level with those established systems. However, in order to deliver a sustainable solution with future commercialisation potential, we designed it according to the WFMC implementation model.

In this section, we provide the state-of-the-art analysis of the Workflow Management System based on the comparison of it to the WFMC Reference Model and to the functionalities of available and emerging systems. In order to characterise the GloNet Workflow Management System and to show its advanced nature, we compare and relate it in this section with the WFMC Reference Model (WFMC-RM) [2]. The common reference model helped us identify the characteristics, terminology, and components fundamental to a workflow management system. We made the GloNet deliverables and the GloNet System compatible to the definition of the basic terms in section 2.1 of the WFMC-RM, namely the Workflow, Workflow Management System, and Process Definition. In the following section, we show how we implemented those concepts in the GloNet workflow management system.

2.5.1 Mapping of GloNet Workflow Management System to WFMC Implementation Model

The WFMC-RC defines in sections 2.3 and 3.2 an implementation model identifying components of a fully-fledged workflow management system as well as interfaces between them. We show this model in Figure 10 and we describe a mapping of each of these components to the GloNet Workflow Management System (WMS) and thereby illustrate the completeness of the GloNet WMS.

![Figure 10: WFMC Implementation Model](image-url)
**Process Definition Tool**

For defining processes the GloNet WMS contains a graphical editor using the BPMN standard as notation (see D3.4), which enables also non-technical people to model workflows. It is easy to define the process activities and their flow of execution. For the more technical parts that modelling experts need to support like associating data to the process activities or invoking external applications. The GloNet WMS incorporates the WFMC meta-model for process definitions defined in section 3.4 of the WMFC-RM. We show the meta-model in Figure 11 and the following list explains how we mapped those concepts to our GloNet implementation:

- Workflow Type Definition maps to Process
- Activity maps to ProcessNode
- Transition Conditions map to the execution flow and gateways of BPMN, which we internally model with the subtypes of ProcessNode (the gateways) and the linkage between the ProcessNodes.
- Role maps to a collection of Candidate Users. Hence, users or user groups in the GloNet System.
- Our process variables store the Workflow Relevant Data. The Glonet workflow management system sets and use the process variables in the process definition. The Process or ProcessNodes link data objects of the GloNet System, such as documents. The data objects of the GloNet System can model additional data that the workflow engine does not use.
- Invoked Applications map to either the GloNet System itself—ProcessNodes of type UserTask—or to external applications. In the latter case, the ProcessNode of type ServiceTask invokes the external applications via calls to their web services.

![Figure 11: WFMC Process Definition Meta-model](image)

In the following, we present how the GloNet Workflow System implements the mentioned WFMC concepts.

**Workflow Enactment Service**

The built-in workflow engine in GloNet constitutes the Workflow Enactment Service. The current implementation assumes one single workflow engine, but conceptually supports distributed workflow engines. The GloNet WMS supports this by modelling separate processes, which synchronize with message passing. Additionally, it supports the distributed workflows in the sense of distributed users of different VO members that participate in a workflow with a single workflow engine. Since the GloNet System is a cloud system, the distributed users can work with one common process execution that coordinates them. Coming back to the Invoked Applications case that we explained above, the ServiceTasks in the process definition implement the invocation capability of the application tool [2].

**Workflow Relevant Data and Application Data**
The process variables store the workflow relevant data. Furthermore, the process definition uses these process variables. The process instance or process nodes link data objects that implement the application data.

**Worklists, Worklist Handler and User Interface**

Since the GloNet System models processes as standard data objects, the GloNet users have an overview—as part of the cockpit or as a list—of the active process steps for them. That is, a view of their worklists.

**Supervisory Operations**

The UI of the Process (Instance) object in GloNet provide the supervisory operations. As we show in Figure 28, the process owner sees the current state of the process and the history of the already completed activities. Additionally, the UI of the Process shows lists of all active processes—both active and completed. Since the GloNet System models processes as standard data objects the user can search, filter, and use them in reports.

**Exposed and Embedded Interfaces**

The GloNet System as a whole and the GloNet WFM are component-based. Consequently, all the boxes in the WFMC Implementation Model have a counterpart in GloNet with an exposed interface. The only exception is the **Workflow Control Data** that is private to the workflow engine. Here, we considered the principle of information hiding more important than exposed interfaces because accessing the control data may alter the semantics of processes.

**Workflow Interoperability**

Concerning the Workflow Interoperability capabilities—explained in the section 3.7 of the Workflow Reference Model by the Workflow Management Coalition—GloNet supports the most advanced form of interoperability at the modelling level as explained in the scenario 4 in the section 3.7.5 of the workflow reference model. Our GloNet WMS does not yet implement the synchronization by messages.

### 2.5.2 Evaluation

The comparison with the WFMC Reference Model and the mapping to it shows that GloNet offers a fully-fledged workflow management system that implements the WFMC reference model. The following topics highlight the advanced nature of the GloNet WFM:

- The GloNet WFM is component-based and therefore exposes all the interfaces defined in the WFMC-RM.
- It supports the most advanced form of interoperability of the WFMC-RM.
- It uses a graphical process definition tool to enable also non-technical people to model workflows.

Compared to the alternative of using an existing standard workflow management system the use of the GloNet WFM has the advantage of that the GloNet System fully integrates it. In this way, process activities can also include executing UI operations of the GloNet System and therefore offer a seamless user experience. GloNet adds to the workflow compliant to the workflow reference model workflow different functionalities for collaborative innovation and service-enhanced products provision. Therefore, GloNet increases the levels of usability of the whole system and offers extra functionalities from which the users of Workflow System benefit in addition to the purely workflow-related functionalities. More importantly, the GloNet workflow specification and execution sub-systems offer seamless integration of the new VO or VBE members without integration efforts. The VBE or VO will therefore not incur expenses derived from the integration projects of legacy systems for the addition of a new member to the organization.
3 IMPLEMENTATION OF THE PILOT DEMONSTRATORS WITH THE GLONET SYSTEM

3.1 Solar plant pilot demonstrator

3.1.1 Solar plant business processes implementation: conceptual framework instantiation

This phase instantiates the main modelling concepts of GloNet for the concrete case of the solar plant pilot demonstrator based on the use case data with the aim of assessing the fitness of the GloNet modelling concepts to represent this particular pilot demonstrator. We firstly describe the stakeholders of the solar plant pilot demonstrator and their roles within collaborative organisational forms that support the pilot demonstrator. Next, we describe the socio-organisational changes to implement in these collaborative organisational forms and stakeholders to implement the solar plant pilot demonstrator.

3.1.1.1 Stakeholders and roles

In preparation for the solar plant pilot demonstrator, we identify and categorise its stakeholders. Next, we model the profile and characterise the stakeholders' roles. Finally, we check the fitness-for-purpose of the modelling templates used.

Figure 12 categorises the main stakeholders involved in the photovoltaic solar plant pilot demonstrator throughout its life cycle based on their area of expertise. Figure 12 sketches the database with the stakeholders' profiles and their general attributes, competences, values, references, and roles.

Some of the stakeholders can do different projects together and therefore motivates to organise them as a virtual-organisation breeding environment (VBE) to capture the multiple repeatable connections between individuals, firms and institutions that constantly shift and expand. The GloNet stakeholders' profiles database facilitates partners' search and consortia creation for new projects. For the pilot demonstrator, organisations use the shared repository of stakeholders at the VBE-level instead of keeping an own isolated record of potential partners like in traditional customer relationship management (CRM) systems.

Figure 13 lists the concrete stakeholders involved in the Charanka solar plant pilot demonstrator together with the countries where they operate and their area of expertise. iPLON inserted the specific attributes of the stakeholders’ profile in the GloNet system.
Figure 13: Concrete stakeholders involved in the Charanka solar plant pilot demonstrator

Figure 14 maps the roles and the identified stakeholders. In the cloud-based GloNet platform, we specify the access rights each role has to the available knowledge and information assets.

3.1.1.2 Organizational forms

iPLON identified the collaborative organisational forms that support the solar plant pilot demonstrator and assess the support functionalities that they provided within GloNet. Figure 15 maps the specifics Charanka solar plant pilot study to the GloNet concepts related to collaborative networks and the different VOs that take part in the different stages of the product life cycle. iPLON defined the long-term strategic networks of the Charanka pilot demonstrator and its goal-oriented networks. The goal-oriented networks target the creation of the Charanka solar plant and its operation.
The pilot demonstrator focuses on the operation and maintenance (O&M) phase of the solar plant and the co-creation of new services through the establishment of the long-term strategic networks and the involvement of local stakeholders. The selection of local stakeholders such as the nine out of eleven that we show in Figure 9 that operate in India deliver a better service close to the customer in the Charanka solar plant.

### 3.1.2 Solar plant business processes implementation: key business scenarios

For the implementation of the solar plant pilot demonstrator iPLON benefited from the GloNet system and concepts with the collaborative networks and the structure of various partnerships under the notions of virtual breeding environments, virtual enterprises/virtual organisations. We replicated in the GloNet system the relevant business scenarios selected from the Charanka photovoltaic solar plant case to compare them with the previously existing and used traditional approaches. We replicated in the GloNet system the relevant business scenarios selected from the Charanka photovoltaic solar plant case to compare them with the previously existing and used traditional approaches.

#### 3.1.2.1 Setting the stage

We used two GloNet sub-systems to set the stage for the rest of the key business scenarios: the VBE Management System and the collaboration spaces of the Cloud-based Platform. More precisely for setting the stage, the end users utilise the VBE Base Management System of the VBE Management System, and the cloud-based platform with the shared resources management, information/knowledge management, and authorised information sharing functionalities.

We emphasise in Figure 16 the main functionalities that supported iPLON in setting the stage with the creation of a VBE community and the VBE in general with the knowledge and information sharing.
iPLON used the VBE Base Management sub-system to describe the solar VBE. Figure 17 shows the roles included in the VBE and a description of the vision and mission of it.

Furthermore, Figure 18 shows the competences, performance indicators, and values of the VBE for the solar plant pilot demonstrator. The competences at the bottom side of the figure are core business competences that companies provide and their areas of expertise. The provision of Operation and Maintenance (O&M) services to support a solar plant is an example of a competence. On the right-hand side of Figure 18 shows the prioritisation of the values of this particular VBE so that the Collaborative Networks Management Environment. The left-hand side shows the performance indicators of the VBE including the number of subscribed members, VOs, shared resources, and brokered opportunities.
GloNet  D6.2

Figure 18: Competences, performance indicators, and values of the VBE for the solar plant pilot demonstrator

iPLON modelled each relevant stakeholder for the solar plant scenario including each member's roles, values, profile data, competences, and rights. Further, iPLON added, as a VBE administrator, these stakeholders to the VBE where they belong. The VBE management system helps iPLON in admitting members to the VBE and withdrawing them. The system checks and makes available the complete member's profile including that member's competences. Each VBE member securely accesses the data according to the VBE member role and membership level. Additionally, the system helps building trust among VBE members due to the performance evaluation for each member.

VBE members are part of a VBE community and can share information in the collaboration spaces at the VBE level with the rest of the members. The cloud-based platform offers this functionality and lets the user give each member the appropriate access rights. Therefore, the VBE sets up the shared assets repository associated to the created VBE with some of the functionalities of the cloud-based platform: the Shared Resource Management and on an indirect manner the Information/Knowledge Management, and Authorized Information Sharing. We show the shared assets repository at the VBE level in Figure 19.
3.1.2.2 Product creation support

iPLON created a complex product with the GloNet functionalities, the Charanka power plant. The photovoltaic solar energy park is a complex and highly customised product with a life cycle of around twenty or twenty-five years. Key business services support the product and add value to the solar plant complex product. We implement the pilot demonstrator as a solar plant in India to validate the GloNet system. The creation of a solar plant requires the collaboration of multiple stakeholders in a global market. The GloNet system supports this collaborative process in spite of geographical distribution with the use of the Internet and collaboration spaces. We show in Figure 20 an overview of the product creation and the main systems involved in the product creation, namely the Product and Service Specification, the VO creation functionalities, and the portfolio repository.

We show in Figure 21 how iPLON started to specify the Charanka solar plant complex product using the PST tool of the PSS sub-system. The Charanka solar plant is a complex product of class power plant and defines three enhancing services and several sub-products.
In Figure 22, we show two branches of the Charanka solar plant pilot demonstrator: the Charanaka POP Monitoring and Maintenance operation and management business services.

After this phase is over and based on this specification, the VO formation context created a virtual organisation (VO) to accomplish the product creation and to provide services to the product. GloNet matched the VBE members to the particular goals that iPLON had defined for the Charanka solar plant pilot demonstrator to form the VO as we show in Figure 23.
In Figure 24, we show the VO created for the solar plant with the potential consortia on the right-hand side.

iPLON moved then to the VO Negotiation support to manage its VO initiative for the Charanka solar plant complex product. We show in Figure 25 the tooling iPLON used to manage the invited partners to the VO.
This goal-oriented network for product development involves multiple stakeholders and the customer itself; that is, L&T. We show in Figure 26 the invited VOs functionality for the client.

The functionalities to support the service-enhanced product and dynamic consortia creation assist iPLON in the product development process. The customers interactively specify the main requirements for product order. Further, the brokerage services help assessing the availability and interest of the manufacturers' network members. The dynamic consortia formation involves the customer and local suppliers in characterising the product order into goals. It also assesses whether the competences gathered in the requirements specification exist in the manufacturers’ network. Additionally, the dynamic consortia formation creates a new consortium for the product development taking into account the trustworthiness of each individual organization, a risk assessment of the potential consortium, and a negotiation agreement specifying the consensus reached among the involved stakeholders.

Finally, the portfolio acts a sort of cockpit that puts together the relevant information on complex products and service-enhancement for further use in other sub-systems and services along the product life cycle of the Charanka solar plant. By doing so, the portfolio enables different VOs to monitor the entire lifecycle of products and the services that they provide. We show an example in Figure 9.
3.1.2.3 Business servicing

The most interesting services we have identified for the solar plant pilot demonstrator are composed services, that we called composite services. For example the site maintenance and performance monitoring business services. The service specification tool (SST), which is a part of PSS sub-system, lets iPLON specify its atomic services and facilitates the creation of composed services. The SST lets end users specify the services that enhance their complex product and sub-products. A complex product needs the support of a large number of business services. End users define a business service as software services or manual services.

iPLON started with the implementation of the one of the business services of the Charanka solar plant complex product; that is, the business service for site maintenance. iPLON implemented with the SST this business service according to how we explained the site maintenance in Section 4.1 of the D4.4 deliverable. Further, iPLON implemented the business services of the pilot demonstrator by using the GloNet concepts, and models. Finally, iPLON matched these business services with the specification of the constituting set of manual and software services in GloNet. The product specification tool supports specifying, re-using, and integrating previously registered manual and software services, to fulfil customer requirements on enhancing the complex product and its sub-products.

As we show in Figure 27, iPLON has used the SST to specify the business service called site maintenance, which has the following upper classes: service, composite service, and cleaning solution. The business service for site maintenance is a composite service, composed of three atomic services, constituting services for: wildlife prevention, check and report, and water drainage. iPLON further specified a set of relevant features for this composite service such as the feature to specify pre-conditions, namely "More than 10 Mbs internet connection", and the feature to specify the capacity as "Up to 10 KM2".
Furthermore, as we show in Figure 27, iPLON has linked the composite business service of site maintenance with its workflow, called "site cleaning-BP", through its Process description feature. To illustrate the execution of the tasks involved in composite services, Figure 28 represents through the workflow engine an example of the use of workflow panel cleaning. On the left-hand side at the bottom the workflow sub-system shows the steps the workflow engine had already executed and on the top right-hand side the next execution steps.

Figure 28: Example of an execution step of the panel cleaning business service

iPLON implemented the performance monitoring business service and the performance monitoring in with focus on the product operation and maintenance activities. In the Charanka solar plant implementation, iPLON integrated their legacy tools for plant monitoring and analysis with the
workflow system of the cloud-based GloNet platform. We used the business service modelling to integrate a monitoring service for multiple stakeholders and the connection to iPLON legacy monitoring systems as Figure 29 shows. To provide this service we selected and organised the goal-oriented network with the VO creation functionalities.

![GloNet System](image)

**Figure 29: Cloud-based GloNet Platform linking to iPLON legacy tools**

iPLON used the VO creation functionalities, including partners’ search and selection, trust and values alignment assessment, and negotiation, to access the shared information- and knowledge-sharing repository. iPLON modelled and registered services and interacted with the other members of the VO formed to design the integrated O&M base service. Next, iPLON integrated their legacy systems for soil loss detection and measuring system with the cloud-based GloNet platform to allow for data sharing with other business partners.

### 3.1.2.4 Co-design or co-innovation scenarios

We implemented the co-design and co-innovation business scenario to solve the low performance ratio problems in the Charanka solar plant. The performance ratio (PR) is a location-independent metric of the quality of a photovoltaic plant and serves as a quality factor. The PR describes as a percentage the relationship between the actual and theoretical energy outputs of a photovoltaic plant. It shows the proportion of energy a photovoltaic plant can feed to the grid after energy loss due to the solar plant operation and thermal or conduction losses. The closer the PR value is to 100%, the more efficient it is. High-performing photovoltaic plants can reach up to 80% PR values. Figure 30 shows the initiation of a co-creation space to find a collaborative solution to the underperforming PR in Charanka solar plant.

![Create new co-creation space](image)

**Figure 30: New co-creation space**

The project developer, TÜV Reinland faced issues with its investors because the plant was underperforming according to the PR. To address this issue three SMEs initiated a co-creation scenario to collaboratively foster creativity to co-design a solution to the low PR problem. The project developer—TÜV Reinland—the client—Larsen & Toubro Ltd.—and the operations and maintenance (O&M) project and service SME—iPLON—decided to co-create a solution together with other
companies and stakeholders in order to co-innovate rather than individually support the current need of their customers. Figure 31 list the three stakeholders that started the co-creation space and shows the GloNet functionality for co-creation member's management. The three SMEs can request new members to join the co-creation space. After the new members accepted, they appeared in the list with Accepted status. The VO negotiation support for co-creation also offers the possibility to specify more co-creation details related to the state of the co-creation, and the participants' roles in the collaborative design. After the formation of the VO for the co-creation process, the initial VO evolved with the analysis of the alternative solutions to the soiling loss measuring system development and associated business service creation. New VOs could have also appeared.

The initiators of the co-design and co-innovation used the GloNet functionalities around co-creation to find a solution to the low PR. They used the multidimensional GloNet tools that combine concepts and processes coming from management, marketing, innovation, knowledge generation, and group decision-making. The GloNet functionalities for co-creation involved the client, Larsen & Toubro Ltd., in the creation of meaning and value and therefore enhanced the management of organizational knowledge. The co-creation learns from the living-labs research concept to blur the boundaries of the project developer, that is TÜV Reinland, and the O&M project and service SME, hence iPLON, for the sake of innovation and co-creation of value together with external sources such as the client, Larsen & Toubro Ltd. In GloNet, the user-centred ecosystem for open-innovation operates in a glocal context a living lab to integrate research, design, and innovation processes. With the co-design implementation, GloNet involves the client as a partner active in the creation of future values.

The co-creation members discussed on how to solve the problem of the underperforming Charanka solar plant. Throughout the process, they documented their co-design of a solution. In Figure 32, we show the documents the co-creation members were using at that moment, namely the product description of the solar plant and its test criteria.
The co-design members selected the blueprint template to describe the nature of the characteristics of the service interaction in detail. With this blueprint, they could verify, implement, and maintain the service interaction with the basic elements on temporal order, timings, and customers' permissions. They can also consider customer and provider actions, support processes, or customer-supplier interactions. We show in Figure 33, the service co-creation templates to check partners' commitment and manage the selection of a template for the co-design.

iPLON co-created solutions and how to trigger the functionalities to manage the counter-proposals. The co-creation members can determine several dimensions related to the attention attraction, information, use, support, and maintainability. The co-creation members used this system until they reached a co-creation agreement proposal. As an example, Figure 34 shows the user blueprint for string monitoring. iPLON monitors every individual string of the Charanka solar plant with this co-created string monitoring solution.
Based on the results of this phase the co-design/co-innovation members came up with the creation of a business service that involves the collaboration among different parties. The automation components for the soiling loss measuring and communication system supported the creation of the services to improve the performance ratio with the use of the soiling loss measurement system and the data collection and transmission system that we show in Figure 35.

Firstly, iPLON detected that an unexpected problem due to the local conditions of the Charanka solar plant near a desert area. Members of the manufacturers’ VBE, local suppliers, and other stakeholders formed a co-creation VO and together created a new business service for soiling loss detection and panel cleaning triggering. The business service requires the collaboration among various companies and uses automation components for the soiling loss measurement and communication. iPLON incorporated this business service and the designed physical measuring systems into their offerings to solar plants in their operation and maintenance portfolio. We used the GloNet functionalities to recreate the main aspects of this business scenario and input them into the cloud-based GloNet platform. Further, in deliverable 6.3 for pilot assessment results and lessons learned we assess the GloNet functionalities based on the experience gathered in the Charanka solar plant. The use of the cloud-based GloNet platform enables remote collaboration, which makes travelling to meetings and the actual face-to-face meetings less fundamental.
The main GloNet functionalities used for this business scenario start with those to create VOs including partners’ search and selection. We also assessed the trust and values alignment and used the VO negotiation support. The co-creation and co-innovation scenario accessed the shared information and the knowledge-sharing repository. We used the collaborative solution space interface and the services modelling and registering functionalities.

We have emphasised the processes and concepts related to the co-design/co-innovation. iPLON specified the services that emerged after the co-design phase with the SST. Once iPLON launched the service, GloNet automatically created the input for VO creation. Then, the VO formation context helped iPLON in creating a list of potential consortia to form a VO. The VO members used the VO negotiation support system to manage the initiative and invited VOs.

3.1.2.5 Other advanced support cases

iPLON wanted to nurture a VBE for their solar plant pilot demonstrator with a long-term collaboration in mind. With the aim of improving the levels of achieved collaboration and enforce a productive cooperation iPLON used the GloNet functionalities to analyse collaborative networks. The emotional evaluation system assesses individual or network emotional elements and proposes corrective or preventive actions to maintain the quality of the collaborative network. It considers the collective emotional health of the networks and assesses the expectations of the collaborative network. The emotional evaluation system improves the traditional supervision and control systems of collaborative networks with the adoption of information and communications technology to handle and support collaboration soft issues.

The emotional evaluation system fosters the collaboration sustainability so that iPLON can profit from a VBE with satisfied members who will be willing to doing business with iPLON and the rest of the VBE. In Figure 36 and Figure 37, we show the collective emotional state of a VBE and the evidences as to how the emotional support system assesses the emotional state of a VBE.

![Figure 36: Collective Emotional State of the solar plant VBE](image)

![Figure 37: Evidences of the Collective Emotional State of the solar plant VBE](image)

Furthermore, in Figure 38 and Figure 39, we show the emotional state of a particular member of a VBE, EFACEC India, and from where this calculation stems.
3.2 Building automation pilot demonstrator

3.2.1 Specification of the building automation pilot demonstrator

One of the areas of expertise of the PROLON GloNet user lies on the building automation business. The building automation operates on a rapidly growing market that optimises and reduces the energy used in modern buildings while keeping the desired environmental conditions. PROLON optimises office buildings of organisations that spend resources in improving the work environment for the people inside the building. These buildings spend energy in heating, ventilation, cooling, and lighting systems.

The personal computers and electronic equipment that we use in today's digital controllers let us effectively and easily automate our buildings. During the past three decades, due to the energy crisis and the concerns of the population and governments about the environment, the public requirements for energy efficiency in newly built buildings make building automation a must-have for new buildings. The low energy consumption requirements are so low that it is nearly impossible to fulfill them without using some kind of intelligent systems to save energy.

Organisations benefit from cost and energy savings together with providing an improved working environment for their employees or people in their buildings. Improved buildings increase their levels of comfort, happiness, and therefore their productivity.

The pilot demonstrator for business automation took a more limited view of the projects in the business area of PROLON. Regardless the fact that a modern building construction project involves a very high number of participants, we focused within the context of the pilot demonstrator on the stakeholders involved in the building automation part of the construction. We based the pilot demonstrator on the knowledge gained from ten previous projects and combined the lessons learnt in an artificial project example. Figure 40 shows the main conceptual blocks of the pilot demonstrator for the building automation.
3.2.2 Building automation business processes implementation: conceptual framework instantiation

PROLON identified eight types of stakeholders and their roles, during the preparation of the pilot demonstrator for building automation, within the building automation part of a construction project. Figure 41 categorises the typical main stakeholders involved in the building automation throughout the life cycle of the pilot demonstrator based on their area of expertise. Some of the stakeholders existed outside the pilot demonstrator and took part in other parts of the building construction project.

Figure 42 lists the concrete stakeholders involved in the pilot demonstrator for the building automation together with the countries where they operate and their area of expertise. PROLON inserted the specific attributes of the stakeholders’ profile in the GloNet system.
Figure 42: Concrete stakeholders involved in the pilot demonstrator for the building automation

<table>
<thead>
<tr>
<th>Organization</th>
<th>Town/City (business)</th>
<th>VBE Member profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>aarsen a/s</td>
<td>Hjørring</td>
<td>yes</td>
</tr>
<tr>
<td>ALECTIA A/S</td>
<td>Virum</td>
<td>yes</td>
</tr>
<tr>
<td>CODEIS</td>
<td>Caparica</td>
<td>yes</td>
</tr>
<tr>
<td>CT Teknik</td>
<td>Køge</td>
<td>yes</td>
</tr>
<tr>
<td>Dominus A/S</td>
<td>Herning</td>
<td>yes</td>
</tr>
<tr>
<td>Insight Building Automation</td>
<td>Silkeborg</td>
<td>yes</td>
</tr>
<tr>
<td>Jysk CTS A/S</td>
<td>Kolding</td>
<td>yes</td>
</tr>
<tr>
<td>Kemp &amp; Lauritzen A/S</td>
<td>Albertslund</td>
<td>yes</td>
</tr>
<tr>
<td>Lindpro A/S</td>
<td>Glostrup</td>
<td>yes</td>
</tr>
<tr>
<td>Prolon Control Systems A/S</td>
<td>Albertslund</td>
<td>yes</td>
</tr>
<tr>
<td>Ramboll A/S</td>
<td>København S</td>
<td>yes</td>
</tr>
<tr>
<td>STRATO A/S</td>
<td>Greve</td>
<td>yes</td>
</tr>
<tr>
<td>STRATO DEMO</td>
<td>Greve</td>
<td>yes</td>
</tr>
</tbody>
</table>

Figure 43 maps the roles and the identified stakeholders. In the cloud-based GloNet platform, we specify the access rights each role has to the available knowledge and information assets.

Figure 43: Roles identification and characterisation

3.2.3 Building automation business processes implementation: key business scenarios

The implementation of the pilot demonstrator for the building automation case helped PROLON with the collaborative networks and the structure of various partnerships under the notions of virtual breeding environments (VBE), and virtual enterprises/virtual organisations (VO). We replicated in the GloNet system the relevant business scenarios selected from the building automation part of the use case for building construction.

3.2.3.1 Setting the stage

For this pilot demonstrator, several organisations formed a VBE and described their competences. As Figure 44 shows, PROLON identified eight types of stakeholders for the building automation case. PROLON initiated the VBE for the pilot demonstrator of the building automation with the VBE Base Management sub-system. Figure 44 shows the profile of the VBE that PROLON initiated for the implementation of the pilot demonstrator for the building automation. It includes the roles and a description of the vision and mission of the VBE.
Table 1 shows the list of the core business competences that companies provide and their areas of expertise because PROLON found out that the hierarchy of competences implemented according to the standard was not enough for PROLON’s needs. The provision of Operation and Maintenance (O&M) services to support a building automation project is an example of a competence.

<table>
<thead>
<tr>
<th>Code</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>C26.9</td>
<td>Manufacturing of automation electronics</td>
</tr>
<tr>
<td>C26.9.1</td>
<td>Manufacturing of automation for building automation</td>
</tr>
<tr>
<td>C26.9.1.1</td>
<td>Manufacturing of light controllers</td>
</tr>
<tr>
<td>C26.9.1.2</td>
<td>Manufacturing of HVAC controllers</td>
</tr>
<tr>
<td>C26.9.1.3</td>
<td>Manufacturing of SCADA system</td>
</tr>
<tr>
<td>C26.9.1.4</td>
<td>Manufacturing of integrated BA controllers</td>
</tr>
<tr>
<td>C26.9.1.5</td>
<td>Manufacturing of BA infrastructure electronics</td>
</tr>
<tr>
<td>C26.9.1.6</td>
<td>Manufacturing of automation sensors</td>
</tr>
<tr>
<td>C26.9.1.7</td>
<td>Manufacturing of HVAC actuators</td>
</tr>
<tr>
<td>F41.2.1</td>
<td>Installation of building automation</td>
</tr>
<tr>
<td>F41.2.1.1</td>
<td>Installation of general equipment</td>
</tr>
<tr>
<td>F41.2.1.2</td>
<td>Installation of ventilation equipment</td>
</tr>
<tr>
<td>F41.2.1.3</td>
<td>Installation of electrical power wiring</td>
</tr>
<tr>
<td>F41.2.1.4</td>
<td>Installation of electrical wiring</td>
</tr>
<tr>
<td>S98</td>
<td>Configuration and integration of equipment</td>
</tr>
<tr>
<td>S98.1</td>
<td>Configuration of automation equipment</td>
</tr>
<tr>
<td>S98.1.1</td>
<td>Configuration of HVAC equipment</td>
</tr>
<tr>
<td>S98.1.2</td>
<td>Configuration of Light control equipment</td>
</tr>
<tr>
<td>S98.1.3</td>
<td>Configuration of SCADA system</td>
</tr>
<tr>
<td>S98.1.4</td>
<td>Configuration of IP network equipment</td>
</tr>
<tr>
<td>S98.2</td>
<td>Test of automation equipment</td>
</tr>
<tr>
<td>S98.2.1</td>
<td>Test of automation equipment, sensors and actuators</td>
</tr>
<tr>
<td>S98.3</td>
<td>System integration of automation equipment</td>
</tr>
<tr>
<td>S98.3.1</td>
<td>System Integration of BMS system with BACnet</td>
</tr>
<tr>
<td>S98.3.2</td>
<td>System Integration of BMS system with LON</td>
</tr>
<tr>
<td>S98.3.3</td>
<td>System Integration of BMS system with KNX</td>
</tr>
<tr>
<td>S98.3.4</td>
<td>System Integration of BMS system with modbus</td>
</tr>
</tbody>
</table>
Furthermore, Figure 45 shows the competences, performance indicators, and values of the VBE for the building automation pilot demonstrator. The competences at the bottom side of the figure are core business competences that companies provide and their areas of expertise. The right-hand side of Figure 45 shows the prioritisation of the values of this particular VBE regarding profit, innovation, agility, interdisciplinary, sharing, and knowledge. The left-hand side shows the performance indicators of the VBE including the number of subscribed members, VOs, shared resources, and brokered opportunities.

The following example that we show in Figure 46 and Figure 47 demonstrates the need for additional competence codes and shows how the refinement allows to select organizations with specific competences on a very detailed level. The following two organizations can install electrical wiring F41.2.1.4, but only the electrical company can install power wiring. Therefore, in a given case, if the product requires 230V volts mains installation the VO formation will, based on capability code F41.2.1.3, need to have an electrical company within the VO.
Based on this scenario, PROLON showed how the light controller sub-product needed some competences and the VOs related to the mains powered class. It shows the VOs that can provide that needed competence in the case of building a light controller.

3.2.3.2 Product creation support

The main key business scenario specified the new complex product of PROLON—building automation—with the PSS sub-system including PST, SST and PSDR tools. The use of these tools demonstrated the reuse of existing specifications for the new complex product for building automation. Furthermore, the GloNet platform formed a VO based on the specification and the organisational competences that PROLON needed to implement for the complex product.

Not all the roles that PROLON specified will participate in the selected scenario as the scenario focuses on the implementation of building automation. As an example, the building owner will not participate in the implementation of the automation system. The scenario will demonstrate the use of the existing and newly created competences to identify four shareholder roles needed for the implementation and will eventually form a selected VO able to implement the desired complex product.

PROLON specified the product hierarchy of the building automation pilot. The main sub-systems involved in the product creation are the PST at first to create the hierarchy and then the VO formation functionalities to associate VOs with the required competences for product creation. Furthermore, the portfolio repository helps in the further phases for design, construction, and operation and maintenance. The main product Floor is an important product within the building automation case and includes the sub-product Office Room with two further sub-products, namely Constant Light and HVAC Heat and VAV. Following the branch under Constant Light, we find its sub-product Light Controller and the three classes it associated to Light Controller namely BA_Equipment, BA_MainsPowered, and BA_LONDevice. These classes lead to the required competencies for the complex product and the required specification of its features. For example, in the case of the Light Controller, hence an instance of BA_Equipment, the sub-product presents features for specifying dimensions. It is also an instance of BA_LONDevice and has the requirement for competency of S98.3.2 or system integration of Building Management System (BMS) with Local Operating Network (LON). So using this device implies that an organization capable of installing LON-based devices should belong to the selected VO for business servicing.

Because it is a BA_MainsPowered device, it requires an organization with electricians, or competency code F41.2.1.3 or installation of electrical power wiring. The code BA_MainsPowered also leads to features like effect usage (Watt) and maximum supply voltage.

Once this phase is over and based on this specification, the VO formation context created a virtual organisation (VO) to accomplish the product creation and to provide services to the product. Then, PROLON matched VBE members to the particular goals that we have defined for the pilot.
demonstrator for the building automation case. PROLON used the GloNet platform to create the VO for the pilot demonstrator for the building automation case with the potential generated consortia. Furthermore, PROLON moved to the VO Negotiation support to manage its VO initiative for the Floor complex product. The goal-oriented network for product development involves multiple stakeholders and the customer itself and includes the necessary competencies defined in Table 1. Figure 48 and Figure 49 show the creation of an instance of the BA_MainsPowered class and how PROLON specified the HVAC Controller in the PST.

The functionalities to support the service-enhanced product and dynamic consortia creation assist PROLON in the product development process. Within this scenario, examples of services are the services to do the maintenance of the building such as lights replacement or services to update of the automation functionalities to meet new requirements. The dynamic consortia formation involves the customer and local suppliers in characterising the product order into goals. In our case, the VO
formation not only considers the product features but also the competences needed. The dynamic consortia formation creates a new consortium for building automation taking into account the trustworthiness of each individual organization, a risk assessment of the potential consortium, and the negotiation agreement that specifies the consensus reached among the involved stakeholders.

Finally, the portfolio repository presents PROLON a dashboard with the relevant information on the complex products for Office Room and service-enhancement for further use in other sub-systems and services along the product life cycle of the pilot demonstrator for the building automation.

3.3 Interoperability requirements of the GloNet pilot demonstrators

The solar plant pilot demonstrator have interoperability requirements to link software services within the cloud-based GloNet platform. We consider the integration of the components in the cloud-based GloNet platform as well as the integration of legacy systems. The developers of the cloud-based GloNet platform took two approaches for the integration of the developed components: the development on top of the cloud-based GloNet platform and the external service integration.

As for the development on top of the cloud-based GloNet platform, the GloNet partners build on top of PaaS services. The GloNet partners developed external services and integrated them with the cloud-based GloNet platform using either a proxy-based or a mashup-based approach. We detailed both approaches in deliverable D3.1.

![Figure 50: Proxy-based and mashup-based external service integration](image)

In the case of the solar plant pilot demonstrator, legacy systems include the solar plant monitoring tools that iPLON has developed which were linked to the cloud-based GloNet platform as external services.

3.4 Conclusions from the pilot demonstrators

The two end users, iPLON and PROLON, moved from traditional sub-contracting practices to the establishment of collaborative networks and partially remote service provision. The changes these two companies had to perform permeated through the whole structure of both organisations. The strive for efficiency and the implementation of a new way of providing services to a complex product affected the business culture and practices with the implementation of collaborative principles and made obvious the need for training the end users.

During this learning process, the end users came to grips with the GloNet conceptual framework throughout the duration of the project through technical discussions between the developers and the end users.

The end users of both pilot demonstrators found very useful how the GloNet system and more particularly the VBE management system allowed them to describe their VBE and the profiles of the VBE members. This included accurately describing their competences and values to see to which
extend each member matches with the rest of the members and with the VBE as a whole. The end users could increase the number of competences to tailor them to the specific needs of their pilot demonstrator. They experienced the strength of the GloNet system to, on the one hand, support a standardised offering fit for commercialisation purposes and, on the other hand, still support the end user that wants to individualise and adapt the implementation to the particular scenario of each pilot demonstrator. Furthermore, they found very easy to map the different roles described in GloNet to the particular VBE members and realised that they needed little effort to implement this.

The Product Specification System let the users of the pilot demonstrator define their complex products and the services available to their customers upon purchase of that product. They reported that specifying the solar plant or the building automation product in GloNet took some effort. The users had to specify the services as well but both efforts paid off when they had to form VOs to build the product, fulfil the operation and management phases, or provide services to the products. They reported the better match of the VOs formed for particular goals.

For every service defined, the end users defined a process for it. They found this particularly useful for the composite services, which comprise a number of atomic services. In that case, the users of the pilot demonstrator launched the product and services to establish their VOs. In a later stage, namely the operation stage, they observed the execution of those processes to monitor the execution of composite services.

iPLON reported that they greatly benefited from the implementation of the co-design and co-innovation scenarios. The implementation took not so much effort from them but enabled them to design together with other stakeholders innovative solutions in a structured and monitored manner. In the long run, iPLON noticed how the overall process and its results improved due to the implementation of the co-design and co-innovation scenarios.

We have considered key performance indicators for both pilot demonstrators along four dimensions: financial, operational, product development, and environment. The financial indicators measure the financial performance of using GloNet in terms of revenue and cost. In that respect, GloNet facilitates the collaboration of geographically distributed stakeholders and in turn increases the efficiency of the process lowering the costs and increasing the revenue. In the solar plant case, the transparency between the partners lowered the need of engineers to travel to the solar plant. iPLON lowered the shipping expenditures with a more efficient policy because of the use of the collaboration platform that avoided multiple shipping of the components to India. The creation of VOs with local partners lowered the shipping costs as well. In the case of the building automation case, PROLON increased revenue with the reuse of services for building automation for following building automation projects.

The operational indicators measure how GloNet facilitates the collaboration for multiple partners working together in a collaborative network. The customer was part of the network and therefore the end users understood better the customisation requirements and reduced the personalisation iterations. In both pilots, sharing information among stakeholders facilitated the tests and implementation of their actual service-enhanced products.

Increased quality of the products serviced and the use of state-of-the-art technology in them increases the product development indicators. The open innovation reduced the duration of the product development cycle of the solar plant and building automation projects.

The impact of large-scale projects in the use of resources and emissions are key to measure the environment indicators. VOs collaborating and sharing resources reduced the impact on the energy consumption of both pilot demonstrators. In turn, they reduced their CO2 emission.

We replicated in the GloNet system the relevant business scenarios selected from the Charanka photovoltaic solar plant case and the building automation case to compare them with the previously existing and used traditional approaches. Although the D6.3 deliverable addresses the detail assessment of the benefits that the end users experienced due to the adoption of the GloNet system.
to perform their activities, in D6.2 we roughly assess the implementation efforts the two end users and the RTD partners incurred. The end users invested five person-months to implement in the GloNet system their pilot demonstrators with their complex products and business services pilot demonstrators. Additionally, the Research and Technical Development partners invested one and a half persons-month in training the end users to use the GloNet system and additional one person-month to adapt the system to the particular needs of the end users. Finally, we consider the costs of running the GloNet system including the fixed costs for hosting and the hotline service provision.
4 CONCLUSION

This deliverable explains the implementation of the two pilot demonstrators for the solar plant and building automation cases. The objective is to validate the approach taken in the GloNet project through the actual implementation of two actual use case scenarios. We show how we applied the concepts and models developed in the span of the work done for this project for the provision of service-enhanced products in the two selected pilot demonstrators. We clarify some implementation details concerning the GloNet system and particularly the synchronisation framework and its interplay with the common data model. The cloud-based GloNet platform includes the GloNet synchronisation framework to enable synchronising the data with external systems or the different GloNet sub-systems. The common data model section shows how each sub-system specifies the meta-model for the entire GloNet system per sub-system. We also explain the single-sign-on mechanisms implemented throughout the GloNet sub-systems to provide a seamless user experience. We present the GloNet dashboard to control the different sub-products along the entire life cycle of a product. Finally, we explain how the we implemented the GloNet workflow management system to address our the specific requirements for the GloNet system while conforming with the WFMC Implementation Model to facilitate the future commercialisation of the sub-system together with the rest of the GloNet system.

During the implementation of the pilot demonstrators, the end users identified and modelled the collaborative organizational forms to then design the operating principles and adjust them to the new organizational structures. The end users assessed the effects of the adoption of new structures for service provision and identified their weaknesses. In response to those weaknesses, the end users communicated with their partners as they instantiate the GloNet system for their particular pilot demonstrators. We enforced user innovation and specific innovative services with the implementation of open technical infrastructure and services. The interaction between various services supplies the capabilities that we integrated into the cloud-based GloNet platform.

The GloNet developer partners put into place JIRA for the management of the integration projects for both pilot demonstrators. By doing so, we invested less effort in identifying potential adoption problems for future end users based on the challenges iPLON and PROLON experience in their adoption. The implementation of real case scenarios gave the consortium the grounds to understand which concepts are difficult to grasp and implement in a real case scenario. Because of this better understanding, new requirements emerged from the integration projects in the context of usability and new functionality to integrate existing data coming from the particular software ecosystem of the end users. The fine-grained description of the pilot demonstrators helped for the implementation in various steps and took into account the parallel developments of the project. The finalisation of the tasks involved in this deliverable allows us to move now on to the actual validation of the project.
5 REFERENCES


Referenced GloNet deliverables:

a. D3.4 - GloNet Platform V 3.0
b. D4.5 - Design and prototype of product portfolio system
c. D6 - Prototype of the Product Specification Tool
CONSORTIUM

CAS Software AG, Germany
Project manager: Spiros Alexakis

UNINOVA – Instituto de Desenvolvimento de Novas Tecnologias, Portugal
Technical coordinator: Prof. Luis M. Camarinha-Matos

Universiteit van Amsterdam, Netherlands

iPLON GmbH The Infranet Company, Germany

Steinbeis GmbH & Co., Germany

SKILL Estrategia S.L., Spain

Komix s.r.o., Czech Republic

Prolon Control Systems, Denmark

Member of the:

www.glonet-fines.eu