D4.5.1a – c-Human Interaction Services 1st Specifications – M12 issue

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ABBREVIATIONS AND ACRONYMS

Abbreviation	Description
c-HI	Collaborative Human Interaction
c-PD	Collaborative Product Development
c-PM	Collaborative Project Management
c-PP	Collaborative Production Planning
BO	Business Opportunity
BOM	Bill of Material
BPEL	Business Process Execution Language
DMS	Document Management System
EC	Enterprise Collaboration
EI	Enterprise Integration
FOAF	Friend of a Friend
HPS	Human Provided Service
ISU	Interoperability Service Utility
PVC	Professional Virtual Community
SaaS	Software-as-a-Service
SOA	Service oriented Architecture
SIOC	Semantically-Interlinked Online Communities
VO	Virtual Organization
VT	Virtual Team
WBS	Work Breakdown Structure
WP	Work Package

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Executive Summary

In this deliverable, we present our vision of human interactions in future networks of enterprises. To ensure efficient collaboration among enterprises, human interactions must be supported by a set of novel concepts enabling seamless integration of human interactions in compositions of services. Enabling effective support for human interactions in service-oriented environments is one major key success factor towards achieving efficient collaboration among enterprises.

In COIN we have to cover several innovation requirements with respect to human interaction support, such as enabling flexible collaborations, network based information sharing, modeling and considering context, and creating participative social software. After identifying these innovation requirements, we introduce c-HI concepts, partially adopted from previous projects, and extended for the COIN collaboration scenario of networked SMEs. Particularly we highlight the concepts of activity-centric collaborations, the role of human- and service interactions therein, and the concept of human provided services. We further examine the role of collaboration context, and introduce the notion of trust between collaboration participants in COIN.

In addition to COIN's innovation requirements, we consider end-user requirements and take the provided business use cases into account, to define concrete c-HI innovative services based on a SaaS architecture. In detail we describe four c-HI end-user tools, and services realizing the aforementioned collaboration concepts. As demanded by end-users, we plan to provide (i) a **Visualization Tool**, for examining network structures and collaboration metrics, including trust, a (ii) tool for **Trusted Information Sharing**, which enables users belonging to different organizations to share project artefacts, (iii) an advanced **Discussion Forum**, which allows to link, search, and utilize human provided services in threaded discussion structures, and (iv) a tool implementing context-aware **Online Support**, either through traditional communication channels or by the concept of human provided services.

1. Introduction

To cope with the dynamic changes of economy and business, companies and individuals have to establish connections between them, create collaboration networks to harvest business opportunities that a single partner cannot realize. In such networks where companies, communities and individuals form virtual organizations (VOs) [CA06], enterprise collaboration support has been a major research track.

The COIN project aims at providing an open, self-adaptive integrative solution for Enterprise Interoperability and Enterprise Collaboration [DOW]. The COIN solutions will be built based on the concept of Software-as-a-Service (SaaS), see for example [GKM+04], and Interoperability Service Utility (ISU) [EIRM08]. With respect to Enterprise Collaboration, COIN aims at supporting various aspects, including collaboration support in product development, production planning and manufacturing, and project management areas for networks of enterprises. As a fundamental aspect, human interactions exist in all forms of collaboration and play a major role in the success of the collaboration within the networks. Therefore, understanding human interactions and providing advanced support for efficient interactions among humans in Enterprise Collaboration, is one of the key objectives in COIN's Enterprise Collaboration research track.

Current collaborative working environments, such as described in our previous study [STD08c], and common collaboration services, such as in inContext[1] and ECOSPACE[2], do not sufficiently support the COIN vision due to complex properties arising in cross-enterprise collaborations. We need to extend current concepts for modeling human and service interactions in networks of enterprises. The lack of tools enabling human interactions in these networks motivates the development of collaborative Human Interaction (c-HI) services.

The remainder of this document is organized as follows. In Chapter 2, we present the role of human interactions and innovation requirements in the COIN project. We propose an agile development approach for the tasks to be performed in Chapter 3. The main part of this document, Chapter 4, outlines new innovative concepts to cover the project's requirements for collaborative networks. In Chapter 5 We propose a SaaS-based architectural design, and explain where our new concepts are located in this model. The innovative services utilizing our c-HI concepts are introduced in Chapter 6, where end-user requirements and typical application scenarios are figured out as well. Chapter 7 covers related work, and in Chapter 8 we state our further plans.

[1] http://www.in-context.eu
[2] http://www.ecospace.eu

2. The COIN project and HI requirements

This chapter briefly introduces the COIN project and its innovations, to which we align our concepts for and development of innovative services.

2.1. Human Interactions in COIN

This section provides a short introduction into the COIN project, and the most important prerequisites for the remainder of this deliverable, such as an explanation of the concept of virtual organizations and the role of human interactions therein, and existing support from FP6 projects.

2.1.1. The COIN Vision

The overall COIN project is motivated by the following vision:

> *"By 2020 enterprise collaboration and interoperability services will become an invisible, pervasive and self-adaptive knowledge and business utility at disposal of the European networked enterprises from any industrial sector and domain in order to rapidly set-up, efficiently manage and effectively operate different forms of business collaborations, from the most traditional supply chains to the most advanced and dynamic business ecosystems."* [DOW]

To support the COIN vision, companies and individuals establish connections to build virtual organizations, where participants can share their expertise and resources. The COIN project aims at providing advanced solutions for setting-up and operating such virtual organizations, dealing with Enterprise Collaboration and Enterprise Integration research challenges.

2.1.2. The Concept of Virtual Organizations

Various definitions of virtual organization (VO) and virtual enterprise respectively, exist, however one of the most common definitions, is the following one adopted from [CA04].

A virtual enterprise is a temporary alliance of enterprises that come together to share skills or core competencies and resources in order to better respond to business opportunities, and whose cooperation is supported by computer networks.

The aim of the COIN project is to support the above concept, thus to ease the connection of legally independent organizations, and to enable them to share their resources. To enable fast formation of collaborative networks, single companies have to be prepared to participate in a VO. This demand is supported by the concept of the VO lifecycle, depicted in Figure 1, and can be separated into four phases:

- **Preparation:** In this phase potential company members get registered and their profiles are created. This accelerates the VO creation process when particular business opportunities have to be fulfilled.
- **Formation (and Planning):** A business opportunity (BO) is either discovered or created by considering the capabilities of all registered single companies. Once a BO has been characterized, i.e. the goals have been defined and the work has been roughly planned in form of a bill of material (BOM) and work breakdown structure (WBS), potential partners are searched, suggested and finally selected to build a VO. At the end of the formation phase, the whole work to be performed is planned and assigned to particular companies.

- **Operation:** This phase covers the actual execution of work, expressed as activities performed by individuals and teams belonging to companies, using various resources and services. In the operational phase the progress and execution of activities is tracked. Thus a holistic view about an ongoing collaboration can be captured. Because collaborations are rarely executed the way they are planned, in this phase valuable information about the success of collaborations can be collected.
  Product Management is a further part of the operational phase, and supports the management of products and parts being developed or manufactured during the operational phase.
- **Dissolution:** In the dissolution phase companies and their individuals get rewarded for their participations in collaborations. Rewards depend on the amount and quality of contribution, and the overall success of collaboration.

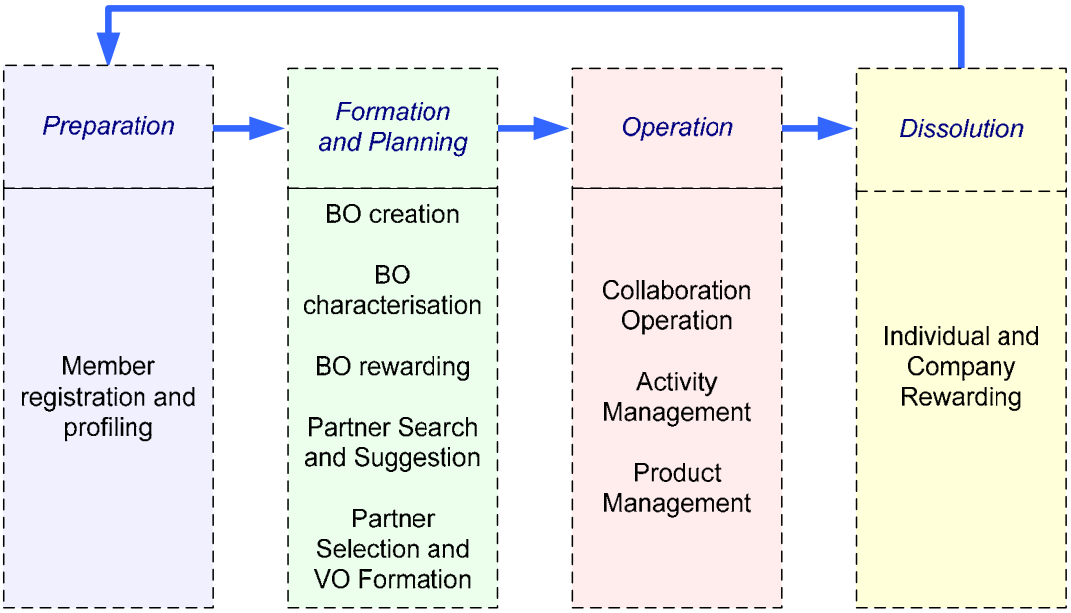

Figure 1: VO lifecycle phases and their supported tasks in the COIN Baseline

2.1.3. Scope of D4.5.1a

The described tasks in each VO phase, outlined in Figure 1, are already covered by services and tools, developed in FP6 projects. One aim of the COIN project is to collect all these tools, and integrate them in a uniform platform, to establish the COIN Enterprise Collaboration Baseline. This has been performed in WP 4.1.

The aim of WP 4.2 to WP 4.5 is to add innovative services, based on this baseline, which extend the use of the COIN framework dramatically. These work packages care about innovative services in the area of *product development* (PD), *production planning* (PP), *project management* (PM), and *human interactions* (HI).

This deliverable is about the role of human interaction support (WP 4.5) in collaborative networks of enterprises, about related innovative ideas within the COIN project, how to realize them, and about the innovative services to be developed.

Our contribution in this work package will be twofold for the overall COIN project. Because we think human interaction support is essential for WP4.2 to 4.4 as well, we will first develop

services which can be used by other innovative services or tools (e.g. in project management). Second we intend to develop tools on top of our own services, which can be used independently from others to support actual workers executing tasks, mainly in the operational phase of a virtual organization, which is currently not well covered.

The focus of this deliverable is to identify innovative concepts for c-HI services; to identify possible connections to the COIN EC Baseline and among innovative services in WP 4.x. The next revision of this deliverable in M24 will then contain a detailed service specification and experiences with first prototypes, after our concepts have been implemented and evaluated.

2.1.4. Goals of c-HI Support

Production planning and project management which is mainly performed in the formation and planning phase of a VO, are supported by services and tools developed by partners of the work packages 4.3 and 4.4, and thus, are already well covered. This includes the creation and discovery of a BO and its characterization by WBS and task structures. However, there is currently only little support for the operational phase, and therefore a lack of solutions to tackle problems arising from dynamic aspects of execution, e.g.., how to handle exceptions and deviations from the plan during collaboration. Thus, once planning is finished, we monitor ongoing collaborations, characterized by human interactions in the operational phase of a virtual organization to retrieve a holistic view about the performance of a collaboration scenario.

This information can be used to identify deviations from planning, and to optimize a collaboration scenario; e.g., by assigning more people or particular resources to ongoing work, if deadlines are missed. Furthermore, knowledge about past collaborations can be taken into account when setting up new collaborations; e.g., previously fruitful collaborations can be considered in the formation phase when selecting partners, or setting up virtual teams. In such cases, besides existing information including competencies, skills and costs, we provide one more aspect, which is trust, to decide which companies or individuals should work together to reach a common goal.

2.2. COIN c-HI Innovation Requirements

We focus on the general COIN innovation requirements mentioned in the description of work [DOW], especially in the S&T objectives and the section about COIN enterprise collaboration state of the art breakthroughs, to derive particular requirements for COIN innovative services for human interaction. Because we understand our services to support other WP 4.x services and tools as well, we also have to investigate requirements of c-PD, c-PP, and C-PM, to find out how our contribution can be a basis for them. The identified c-HI requirements are outlined and shortly described in this section, and are the basis for the c-HI services specification.

2.2.1. Cross-Enterprise Context Model

The major drawback of existing solutions is the lack of cross-enterprise context models. Several projects from FP6 aimed at providing context models to describe the overall situation of work within a team or within a whole organization. The focus in COIN is broader, which means we focus on cross-enterprise context. Thus, a *scientific analysis of collaboration context including modeling in machine-readable patterns* will be performed to support COIN's innovative ideas. This includes solutions for context sharing between different organizations and context merging, which both may be supported by enterprise integration services from WP5.

2.2.2. Innovative Interaction Model

We consider both *humans and software services participating in a collaboration scenario*. Thus different kinds of interactions between different actors can be distinguished, and have to be supported by our interaction model.
Each user should be able to use the human interaction services *at any time, in any place, with any device*. Technically, it can be achieved through advanced software engineering concepts, such as Web services, portal, and mobile support. The key challenge is to support a rich set of interaction patterns, such as delegation, proxy and broker which requires extensive knowledge about human capabilities.

2.2.3. Collaborative Network Model based on Human Interactions

As mentioned before we consider both kinds of actors, humans and software services, acting in a collaborative network. Every actor, having his own goals, context and attitude, is modeled in this network, and relationships between these actors with respect to previous collaboration experiences and collaboration context.
As stated in the [DOW], major problems in c-PM are raised by *human-related issues like trust, compatibility, collaboration spirit and attitude*. All these issues can be reduced to human interaction issues, thus, improving the quality of human interactions helps to tackle these problems.
Our aim is to establish a network of entities and to quantify the relations between them with respect to situational context. This will help to support *decision making depending on current situation*.
One major impact to decision making, as mentioned before, is trust. For instance, for partner selection or the assignment of tasks to other people, trustworthy information about their capabilities, collaboration behavior and attitude to work is needed. In our view, trustworthy information is mainly obtained by observing interactions within collaborations and analysis of provenance data.

2.2.4. Flexible Collaboration Support

A major objective is the *flexible and dynamic cooperation support by means of self-managing and collaboration context based on activity orientation.* These self-management functionalities will be supported by human interaction analysis and analysis of past collaboration scenarios reflected by task structures and activity flows, to find out who collaborates best with whom in which situation by using which resources and services.

2.2.5. Participative and Social Software

This kind of software allows advanced user participation such as in *Collaborative Decision Making*. This requires exploiting advanced techniques in Web 2.0 and Enterprise 2.0 to support user participation with dynamic portals and mashups. A particularly important point is to allow the user to participate in the analysis of human interactions with respect to the context of interest. This will require *advanced analysis techniques, possibly user-specific queries and context-based interaction analysis*.

2.2.6. Network based Information Sharing

Information Sharing is about the *seamless access of results of collaborations among enterprises*. These results can be represented by either common artifacts, such as reports and documents, but also the knowledge or expertise of collaboration partners. Thus, only a common document repository is not sufficient any longer. We need a kind of online response service to establish a knowledge network between actors in a collaboration scenario. Combined with the previously mentioned collaboration network model, a cross-enterprise aware context model and self-adaptation mechanism, the goal is to *provide decision makers*

*with the right knowledg*e in particular situations reflected by the collaboration context model. The Collaboration context model is important because information is bound to specific contexts, thus, if information is used out of the context or the context is not matched, the value of information is reduced. This is they way we follow to develop *applications for groups of users and communities belonging to networked organizations.*

2.2.7. Innovative On-Demand Utility-Oriented Business Model

Recently, the software-as-a-service (SaaS) model, see for example [GKM+04], has been considered as one of the main models for current and future networked enterprises. Currently, various enterprise solutions are provided under SaaS model, such as Salesforces[3]. With SaaS, software will be provided as a service which can be leased, composed, and utilized by different consumers without worrying about the deployment and maintenance of complex software. The COIN software model is built on the SaaS model [DOW], allowing a flexible mechanism to develop, compose and utilize software for enterprise collaboration. For collaborative working environments in general and for networked enterprises, we advocate the use of SaaS for building commodity collaboration services [Sko08]. Therefore, the concept of SaaS will be utilized for the development of c-HI innovative services.
The main software model of COIN is SaaS-U (Software as a service utility), thus our human interaction services will follow this model. This requires us to define interoperable context models, agreed metrics, and human interaction data representation to ensure that the services can interoperate with other SaaS-U in COIN.

[3] http://www.salesforce.com/products

3. Innovative Services Development Approach

For the development of innovative HI-services we follow an agile development process depicted in Figure 2. Basically we start with analyzing the COIN innovations described in the description of work [DOW], to ensure we incorporate new and innovative ideas aligned with the overall idea and mission of the COIN project. Furthermore, we take the end user requirements collected in [D6.1.1a] concerning HI services into account and consider technical requirements such as the use of a common service platform or tools portal, including techniques from WP5 partners to support enterprise integration technologies. Then we design the architecture of c-HI services for networks of enterprises in which humans and services interact with each other to perform given activities. Based on this design we implement the c-HI services and test them with respect to the specified requirements.
Human interactions take place for a particular purpose bound to a particular context. This means humans interact with other humans or services when they perform their work, such as developing products, planning production or managing projects. Because we understand the support of human interactions as a basis for other work packages' contributions, we analyze the results from work packages 4.x partners to identify how our c-HI services can be used to support services and tools in collaborative product development (**c-PD**), collaborative production planning (**c-PP**) and collaborative project management (**c-PM**). In at least one refinement cycle, which considers new requirements, changed ones and the outcome of other work packages, we repeat the last three steps to adapt the system according to the end-users needs and to utilize possible synergies with other partners to the best.
In a last step we will verify the results with respect to the innovative COIN targets, and the end-user requirements.

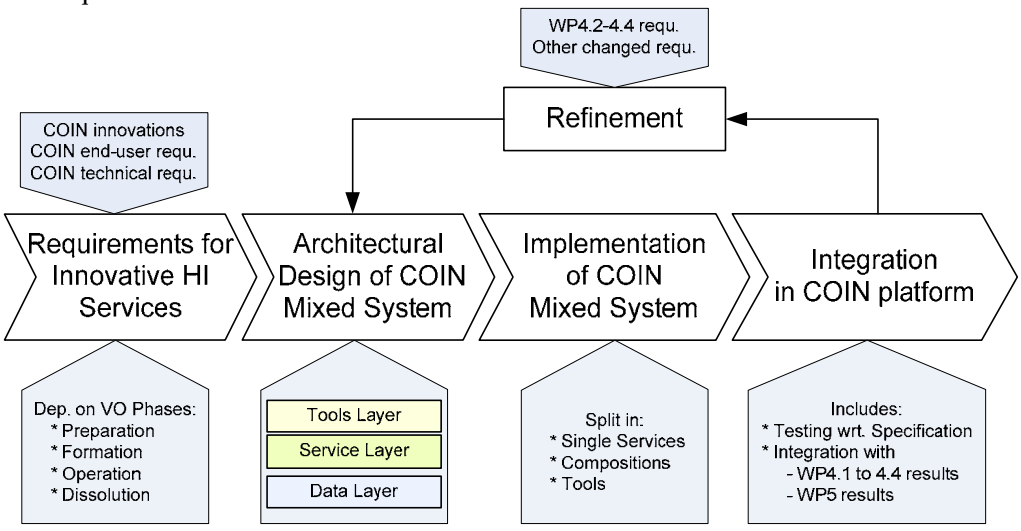

Figure 2: Agile development process for innovative c-HI service

4. Innovative Concepts for Human Interaction Services

This chapter outlines how previous project results (i.e., inContext) can be reused to support innovative human interaction services in COIN. Previous results include: (i) **model of activity-centric collaboration** enabling ad-hoc collaborations, (ii) the definition of various **human and service interactions** in SOA, (iii) the notion of **Human-provided Services**. We introduce new innovative concepts to support human interactions in future networked enterprises: (i) **advanced interaction concepts**, (ii) the COIN c-HI **trust model**, (iii) approach, use-cases, and **innovative applications scenarios** illustrating our vision of future networked enterprises.

4.1. COIN c-HI Basic Concepts

Basic c-HI COIN concepts comprise human actors, an model of activity-centric collaboration denoting "what a user does" in a collaborative working environment (CWE), for example, **actions** such as "writing documents", "sending emails", or "working on a task", and a **context model** capturing the different concepts. Furthermore, **Web services** play a fundamental role in modern CWE. In our conceptual approach, Web services are used "like" **tools**, which can be **composed** to realize certain features. We distinguish different levels of formalism in collaborations ([Dus04], [STD08a]):

- **Ad-hoc processes**: collaboration structure that is characterized by a set of **human activities** which are not modeled in advance. Instead, such ad-hoc activities emerge during collaborations and interactions. Such "semi-structured" processes can usually be found in creative collaboration scenarios where team members attempt to solve a problem or work on flexible human activities, for example, "Todo Lists".
- **Formalized processes**: well defined **process activities** modeled in advance. Such activities are enacted at run-time using Web services. The exact flow and purpose of formalized processes is well specified. For example, the Business Process Execution Language (BPEL) is a language targeted at modeling and execution of formalized processes.

Ad-hoc processes and semi-structured collaborations are the central focus of concepts and foundations presented in this work. While certain predefined structures (for example, a work-breakdown structure in "machine assembly processes") define the most important steps in a process, certain ad-hoc activities need to be supported using c-HI.

Our roadmap for the remainder of this chapter can be summarized as follows:

1. We detail the basic model of activity-centric collaboration supporting ad-hoc and semi-structured collaboration scenario.
2. Web services play a fundamental role in supporting flexible, cross-enterprise collaboration scenarios. We detail human and service interactions in future networked enterprises. Various collaboration scenarios can be supported through the Human-provided Services (HPS) concept. In this document, we provide the required background of HPS and show how HPS interactions models can be used and extended to fulfill the requirements of COIN. We introduce advanced c-HI interaction models illustrating our ideas.
3. Finally, we introduce the COIN c-HI trust model and fundamental concepts supporting cross-VO collaborations.

4.1.1. Activity-centric Collaboration

In this section we start with a simplified view on activity-centric collaboration in service-oriented environments. The basic model of activity-centric collaboration as shown in Figure 3 allows collaborations to be structured around the concept of **ad-hoc activities**. This model describes the management aspects such as responsible and involved users, time constraints, skill requirements of involved people and applicable resources, for example services. The action concept enhances activity design-time aspects with "runtime information". Such runtime information includes a set of actions such as delegation, coordination and communication. The action concept provides the fundamental input for deriving various collaboration and trust metrics.

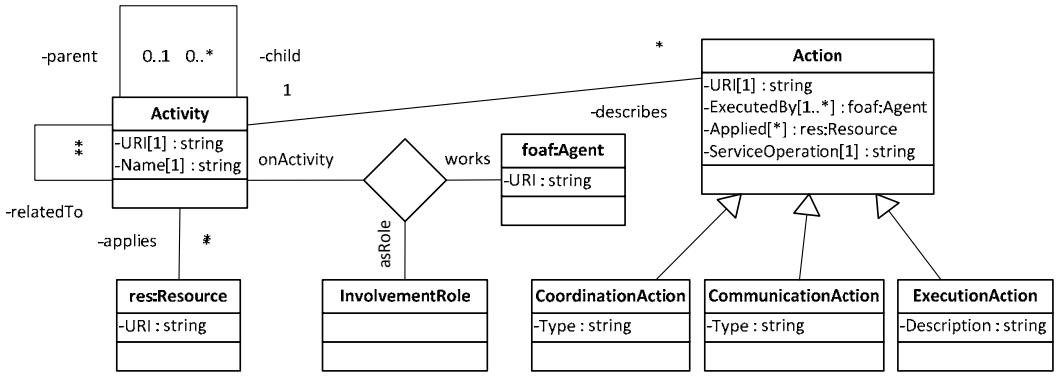

Figure 3: Model of activity-centric collaboration (excerpt [DSD08])

4.1.2. Human and Service Interactions in SOA

Based on the notion of activity and service-orientation in collaborative environments, we discuss basic interactions scenarios, which we will subsequently extend to capture the requirements of c-HI in COIN. In the following, we define notation and semantics of various symbols used in this document:

Definitions and semantics:

In the following discussions and figures we denote a human or a service as circles, lines between circles entail a connection between two entities, say between human *a* and human *b*. A dashed line with arrows at both ends depicts interactions, for example, with the purpose of information and context sharing.
HPS abbreviates Human-provided Services which are denoted by a special **compound symbol** – document shaped symbol with embedded diamond symbol (denoting a human activity) and a user icon. A set of entities usually operate (e.g., affiliated with) in a certain **scope**. We denote those scopes by surrounding entities and connections with spheres. Notice, we make no assumptions how these scopes are determined or how the implementation of such scopes looks like.

As stated before, Web services play a fundamental role in supporting flexible, cross-enterprise collaboration scenarios. In the following, we revisit human and service interactions as introduced in our previous work (inContext). Based on these interaction scenarios, we will establish new concept targeting cross-VO scenarios specifically based on COIN requirements.

Figure 4 depicts the foundational interaction scenario found in human and service-oriented systems.

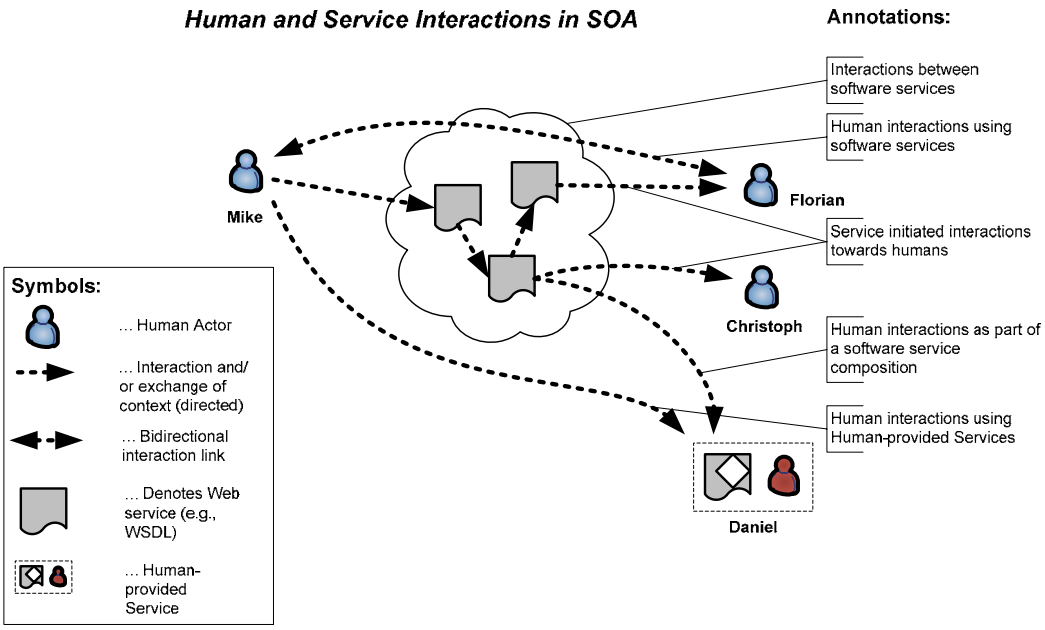

Figure 4: Human and service interaction scenario in SOA[4]

The following definitions are illustrated as annotations in Figure 4.

- **Interactions between software services**: such interaction scenarios are found in compositions of software services. For example, output of service A is used as input by service B.
- **Human interactions using software services**: services can be used to realize collaboration functions in a flexible manner. Users are able to use services (the representation frontend) to perform collaborations. Typical human-service interactions include map services, document sharing service, etc.
- **Service initiated interactions towards humans**: such scenarios include notifications or news feeds, which are **pushed toward** the user.
- **Human interactions as part of software service compositions**: many service interaction scenarios demand for human interactions. A popular example is BPEL4People[5].
- **Human interactions using Human-provided Services**: Our previous work included the support of service-human interactions (e.g., see [STD08a, STD08b]), allowing humans to express and offer their capabilities as services.

[4] inContext deliverable D1.2 (Discovering Service-Interaction Patterns - Methods and Mining Algorithms)
[5] http://www.ibm.com/developerworks/webservices/library/specification/ws-bpel4people/

4.1.3. Human-provided Services

We briefly highlight basic steps to support HPS based interaction and collaboration scenarios. The HPS framework[6] provides fundamental features:

- **Definition of services**: anyone can define his/her capabilities which are exposed as services and corresponding interfaces.
- **Specification of interactions**: users are able to specify their personal interaction protocol.
- **Provisioning of HPSs**: services can be published and provisioned in ad-hoc collaboration scenarios as well as formalized processes (e.g., as mentioned in previous scenario).
- **Discover and interact with other users/processes**: by discovering services provided by humans, a user can include other HPSs in his/her processes.

HPS provides fundamental techniques for humans to express their capabilities as services and to collaborate with each other through these services. HPS is a flexible approach supporting versatile collaboration scenarios. Thus, we can utilize this concept in various (dynamic) environments.

4.2. Advanced c-HI Interaction: Models and Concepts

We introduce interaction concepts helping modeling human and service interactions across various contexts. Such contexts include, for example, cross-enterprise (VO) collaborations and interactions. These interaction scenarios demand for concepts such as **information sharing**, **flexible control**, and abstraction of human capabilities as HPSs.
Let us first start with a discussion of various interaction scenarios depicting the need to support context-awareness and versatile interaction scenarios. Such interaction scenarios typically span humans and (software) services.

The first concept illustrated in Figure 5 can be described as a **broker**. The set of entities *b*, *c*, *d*, and *e* are connected (operate) in *scope 1*. The broker a controls the information and context exchange between *scope 1* and *scope 2*. This can be accomplished by interactions with entities in *scope 1* (entity *c*) *scope 2* (entity *f*).

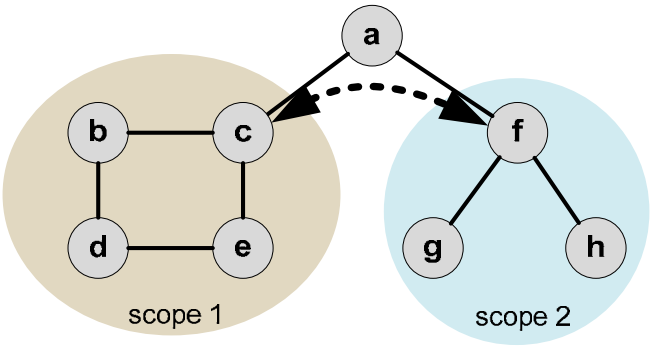

Figure 5: Broker concept connecting independent scopes

However, in this example we assume that the **broker** does not necessarily attempt to inform entities in *scope 1* and *scope 2* respectively about its control of information and contexts.

[6] HPS Wiki page: http://berlin.vitalab.tuwien.ac.at/autocompwiki/index.php/Human-provided_Services

In some cases such separation of scopes is well desirable, but other collaboration and interactions scenarios may demand for shared contexts (**scopes**).

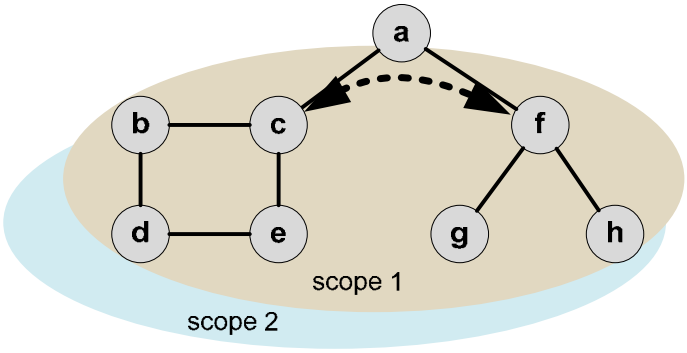

Figure 6: Broker connecting scopes with the aim of enabling shared context views

In Figure 6 we show a broker which merges two independent scopes with the goal of establishing a shared context between *scope 1* and *scope 2*.
However, merging of contexts may not only cause conflicts, but also privacy and security concerns. In Figure 7 we show *scope 3* established for the purpose of syncing entities *a1* and *a2*. Such synchronizations are done on behalf of entities residing in *scope 1* and *scope 2* respectively. We call such interactions scenario **delegates with shared, abstracted views**.

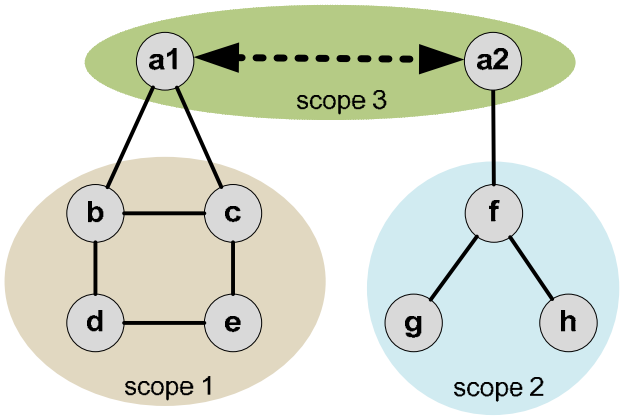

Figure 7: Coupling of scopes by introducing a shared scope between delegates

In the following, we introduce an interaction scenario which is more rigorous in terms of connecting entities within *scope 1* and *scope 2*. Entities *c* and *f* as well as *e* and *g* are connected with each other, thus introducing stronger ties between both scopes. However, both connections that were introduced for the purpose of merging, for example, the ability to interact with entities in different scopes can still be restricted to operate under certain conditions (*scope 3* and *scope 4*).

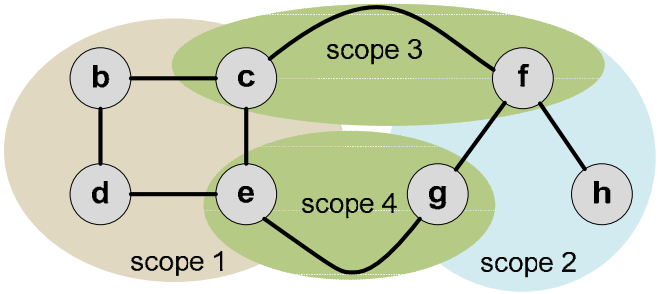

Figure 8: Mashing connections between entities

4.3. Advanced c-HI Interactions: Context and HPS Support

In this section we emphasize how previously introduced concepts can be realized using human interactions services and context techniques, for example, context sharing.
In Figure 9, the concepts described in Figure 5 (corresponding to left part of Figure 9) and Figure 6 (corresponding to right part of Figure 9) are detailed enabled through activities and services (HPSs for example).

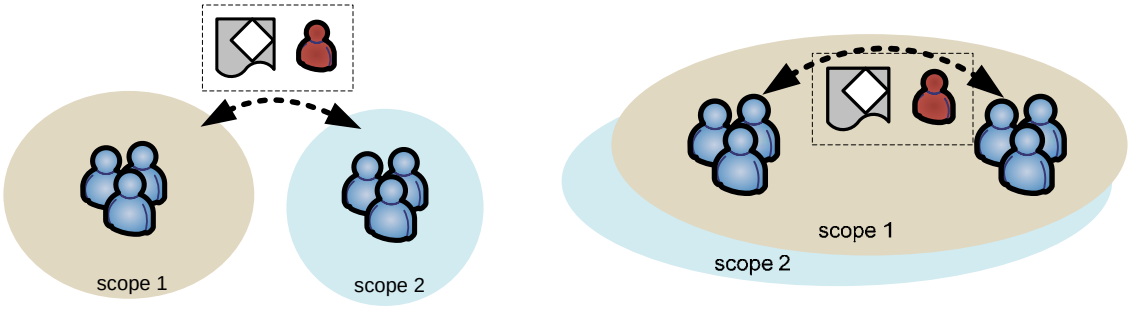

Figure 9: Supporting different brokering scenarios through human interactions (HPS mediated) and context sharing techniques

In Figure 9 (left) we show a HPS acting as broker for two scopes. Such scopes might comprise a set of users (e.g., teams or VO). The HPs broker connects both scopes without establishing a shared context, whereas in Figure 9 (right) we show an HPS whose goal is to connect both scopes through context-sharing techniques.

Next, the concept **delegates with shared, abstracted views**, as depicted in Figure 6, is demonstrated in Figure 10. Users situated in each scope may be nominated to act as delegates (e.g., representatives) using *scope 3* to share information, context, and perform interactions. Specifically, if organizational structure as well as details regarding collaboration structure may not be exposed and shared across scopes, we favor such architectural views.

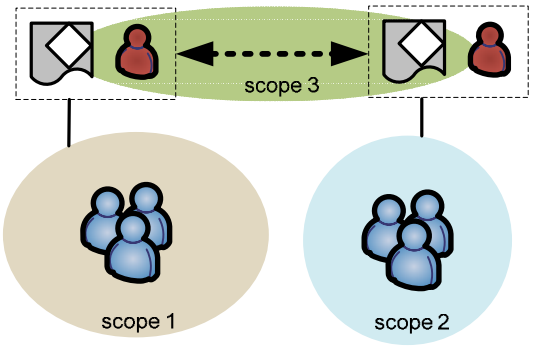

Figure 10: Delegates for abstracted scopes

Finally, based on the definition of a mashup-like scenario (i.e., Figure 8), we demonstrate the HPS support for such scenarios in Figure 11. Multiple users offering HPSs are connected with each other, therefore introducing multiple interfaces for exchange of information and context.

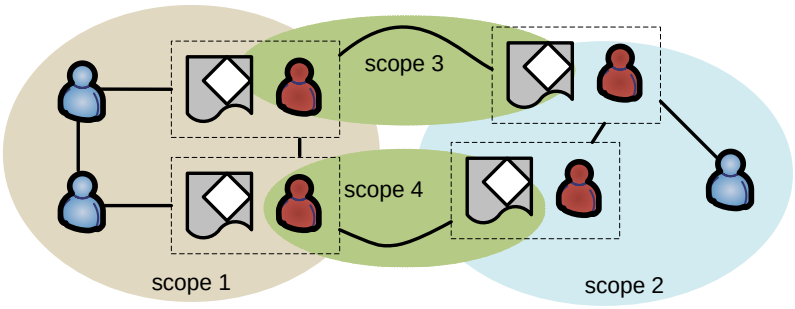

Figure 11: Mashing connections into disparate scopes

However, various information sharing techniques (e.g., permission to access information at certain granularity level or even document routing across scopes) help to prevent unauthorized access (e.g., delimited by *scope 3* and *scope 4*).

4.4. COIN c-HI Trust Model

In collaboration scenarios where people work together to reach a common goal, not only their professional competencies, but also social factors influence the overall collaboration performance. In COIN, skills and competencies management is already well covered by existing services from FP6 projects; however, social influences are currently widely neglected. One composed and abstract concept which aggregates and expresses social influences on a relation between humans is **trust**. Trusted relationships are vital to the whole collaboration process and a prerequisite to success.

A recent report about the roles of trust in today's business world [Eco08] surveyed several hundred companies to find out, what are the main influences for establishing trust. The authors found out that besides professional skills expressed as experience, expertise and competence, soft skills such as the willingness to exchange information, motivation and communication skills are at least equally important as well.

This motivates us to investigate the concept of trust, and research how these concepts can be applied in COIN to support collaborations and improve their results.

4.4.1. Definitions of Trust

Trust has been defined in several different ways, depending on the research area. Even in the field of computer science there are various definitions according to security and access control for computer networks, reliability in distributed systems or policy oriented trust for decision making. Regarding service oriented architectures for collaborative environments the following well-known definitions seem to be feasible.

> *Trust is the subjective probability by which an individual A expects that another individual B performs a given action on which it welfare depends.*
> [Gam90]

> *Trust is the extend to which one party is willing to depend on something or somebody in a given situation with a feeling of relative security, even though negative consequences are possible.*
> [Mc96]

> Trust is *a subjective expectation an agent has about another's future behaviour based on the history of their encounters.*
> [Mui02]

> Trust is *the firm belief in the competencies of an entity to act dependably, securely, and reliably within a specified context.*
> [GS00]

> *Trust of party A to a part B for a service X is the measurable belief of A in that B behaves dependably for a specified period within a specified context (in relation to X).*
> [ORM+05]

4.4.2. Definition Issues for COIN

The itemized definitions have several widely adopted concepts in common, which we utilize to define our notion of trust especially for the COIN collaboration environment:

- Trust describes the **relation between** exactly **two entities**, which may be people, but in a service oriented environment also services.
- Trust relations are established **with respect to particular situations** and for particular purposes, both reflected by contextual elements, which are described by activity structures, project information, task requirements etc.
- Trust is **determined by competencies of entities,** and **previous collaboration encounters** and experiences. In COIN competencies are managed in the centralized database, features of services may be retrieved from a service registry. Collaboration encounters can be monitored as long as they take place using dedicated services (e.g. communication via e-mail or IM), or document sharing through a DMS.

Derived from the above definition of [Mui02], trust between two persons is established based on their history of interactions, thus, if people work successfully together for a longer while, we think trust can be inferred by monitoring and analyzing their past collaboration behaviour. Particularly in cross-enterprise collaborations and virtual teams, where most participants are not able to establish personal relationships, trust has to be mostly determined by the success of past collaborations and the quality of the outcome only. Thus, we argue that one's trust in another one is higher the more efficiently and successfully both collaborated in the past, and both performed in the same activities well [STD09].

In COIN's collaboration scenario success and efficiency depend on the competencies of people. Competencies are either hard skills expressed by formal educational levels and certificates, or soft skills, such as the openness in discussions or the willingness to be a team player. From this perspective, we adopt the above definition from [GS00] as well.

According to this definition, trust is context dependent, which means trust between two actors is determined particularly for a given situation. Context reflects situational information, such as the activity to be performed, its requirements, other participants, utilized services, used resources, the overall project to finish or goal to reach etc.

Thus, we define trust specifically for the COIN collaboration scenario as follows:

Trust is an expectation based on previous collaboration experiences, one entity has about another's future behaviour to perform activities dependably, securely, and reliably within a specified context.

4.4.3. Basic Trust Network Concepts in COIN

With respect to above definition of trust we model trust as a directed relationship from one entity trustor to another entity trustee, as depicted in the left picture of Figure 12. We define trust generally to be established between entities, which are humans or services in the COIN collaboration scenario. The role of a **trustor** expresses that an entity **trusts** another one, while the role of a **trustee** reflects that an entity **is trusted** by others.

Trust relations between entities are mostly modelled as complex networks. We show the basics behind such models in Figure 12 to familiarize with the underlying concepts.

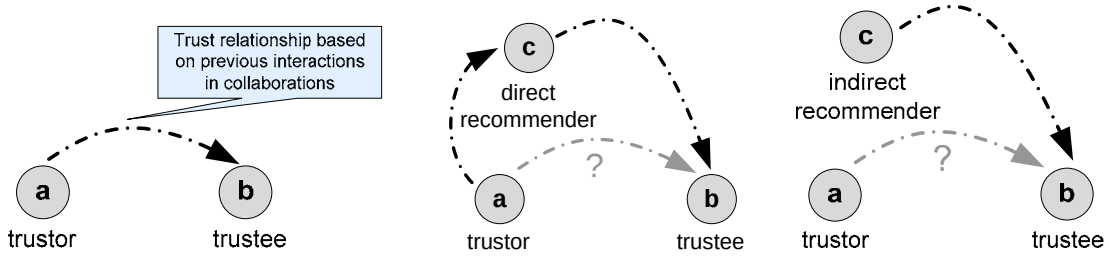

Figure 12: Trusted relationships between entities

On the left side a direct relationship from the trustor *a* to the trustee *b* has been established based on interactions in previous collaborations and personal experiences. Between humans, typically such relationships are built if the trustor and the trustee collaborate for a longer while and they get familiar with each others' working style, including the quality of work, the person's reliability, etc. Direct relationships reflect first-hand experiences and provide the most reliable information for trust of a particular entity in another one; however, especially in professional collaboration environments such relationships are typically rare. This means someone normally doesn't establish direct trust relationships by considering first-hand experiences to many other entities.
In the COIN collaboration scenario where hundreds of organizations work together and build VOs with several hundred to thousands of members, using hundreds of services, considering only direct trust relationships would decrease the usefulness of the trust concept. Hence,

possibilities to derive trust between two entities which never interacted directly before are needed. Two scenarios are depicted in the middle and right side of Figure 12.
The centred picture shows, how a trustor *a* infers a notion of trust to the trustee *b* by considering the relationship to a well-trusted entity *c*, which also trusts the trustee. This concept is called **recommendation**, and applies transitivity, which implies that if *a* trusts *c*, and *c* trusts *b*, then *a* can also trust *b*. Thus, *c* recommends *b* to *a*. Then, *a* takes its own relation to *c* and the relation from *c* to *b* into account, to derive its (*a*) trust relation to *b*.
On the right side it is shown that trust can also be inferred from not related indirect recommenders. This means even if the trustor *a* has no direct relationship to recommender *c* he can rely on its relation to *b*. This concept is especially useful if there are several entities which established a trust relationship to the trustee. Then their opinion can be aggregated and used by others. The result can be interpreted as **reputation**, expressing how well an entity is trusted by others on average.

4.4.4. Scope of Trust

It is widely agreed that trust is context dependent [GS00] [Mui02], which means trust is established for particular situations. As mentioned before, contextual information in the COIN collaboration scenario reflects for instance running projects, performed activities, previous experiences and collaboration encounters, team compositions, and company affiliations.

The left picture of Figure 13 depicts that trust relations cannot be determined generally, but with respect to a particular scope. This scope, which is determined and described by contextual data, has multiple dimensions, but for example in a simplified case, a human trustor *a* might trust the trustee *b* to organize a meeting (*scope 1*), but not to develop a new particular product (*scope 2*). In this case scopes are obviously different and not closely related to each other. However, there are cases where scopes may be similar. For instance, the trustor might have established trust to the trustee regarding software implementation (*scope 1*). This means the trustor can trust the trustee to perform assigned activities in the area of software implementation reliably in the given time with the required quality. If the trustor wants to know how much he can trust the trustee with respect to software testing activities (*scope 2*), trust can be inferred from the relation regarding software implementation, because both implementation and testing are part of software development, and thus activities have similar requirements. Hence, the concept of trust scope allows (i) deriving relations for new situations based on relations in other, but similar situations, and (ii) distinguishing trust relations with respect to different scopes and thus, expressing trust relations more precisely and reliably.

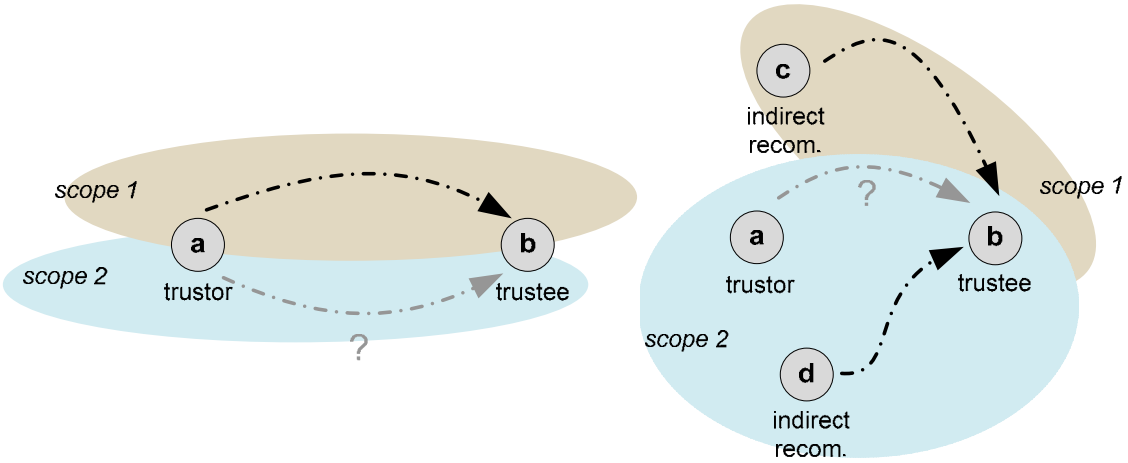

Figure 13: Role of trust context

The use case depicted in the right picture of Figure 13 shows exemplary how the concept of trust scope is applied in the previously described trust network concepts. In this scenario the trustor *a* is not aware of the trust level in the trustee *b*. This doesn't mean that *a* distrusts *b*, this simply means *a* didn't collaborate with *b* in the past, thus *a* doesn't know how much to trust *b*. Let's assume the trustor *a* wants to collaborate with the trustee *b* in a software implementation activity (*scope 2*) and there are two indirect recommenders, who collaborated with the trustee *b* in the past. Indirect recommender *c* trusts the trustee with respect to software testing (scope 1), indirect recommender *d* trusts *b* with respect to software implementation (*scope 2*). The trustor *a* derives a notion of trust in the trustee *b*, by taking both recommender's relationships into account. Intuitively the *a* will rely more on *d*'s opinion about *b*, because *d*'s relationship has been established regarding software implementation, thus with respect to the same scope. However, *c*'s relationship with respect to software testing may also be of interest, because *scope 1* and *scope 2* share similar properties to a certain extent. Both relations from *c* to *b* and from *d* to *b* can be aggregated, so that trust of the trustor *a* in the trustee *b* can be determined with respect to software implementation, based on *b*'s reputation.

In real scenarios context reflecting real situations, has several dimensions. It is a challenging research question, how to model this collaboration context and furthermore, how to determine which elements are most important in particular situations.

By considering context data, we plan to exploit information about who works with whom how well with respect to which activities together. After an initial phase of collecting such information, we shall be able to recommend team compositions and collaboration partners in situations, which are similar to previous ones.

4.4.5. Data for Determining Trust

Trust of one entity in another one relies on various factors and is influenced from many sides. We discuss exemplary which sources have to be taken into account, to determine trust of one person into another one (Figure 14).

Utilizing the concepts of previous subsections, **basic trust network concepts** and **scope of trust**, we outline important factors impacting trust of a trustor in a trustee with respect to *scope 2*. The most obvious ones are itemized and further explained in the following list.

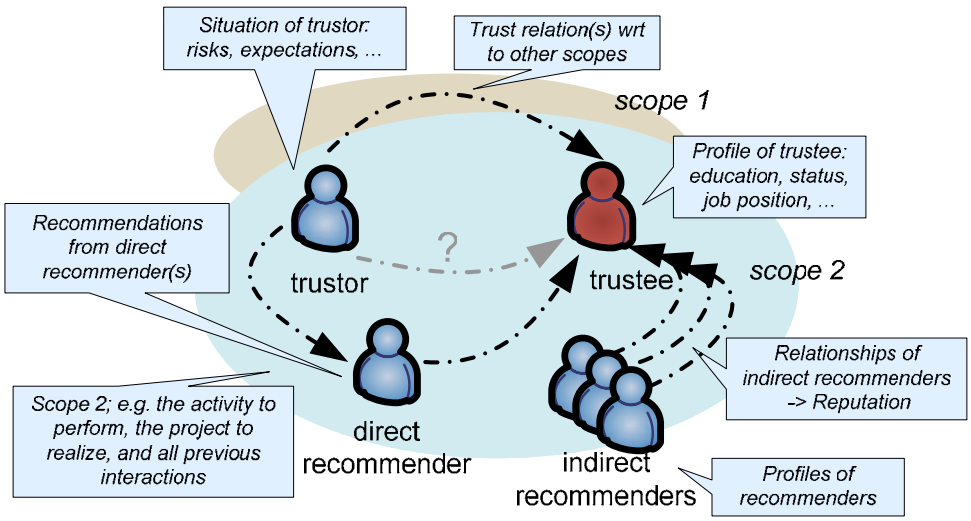

Figure 14: Data influencing trust determination

- **Profile of the trustee**, such as his educational status, job position etc. This is utilized, e.g. when it comes to collaboration partner selection or activity assignment, than it can be determined if the trustee owns the formal competencies to be trusted to perform a given activity reliably.
- **Situation of the trustor**, such as his risk and expectations with respect to a particular situation. Decisions about whom to trust always depend on the risk the trustor has to bear. Let's assume the trustor wants to assign the trustee a particular activity. If the negative consequences for the trustor are high in case the activity is not performed well, than the trustor will not trust the trustee carelessly.
- **Scope**, describing the activity to perform or project to realize. Furthermore, all **previous interactions** with respect to a particular context can be aggregated to determine trust.
- **Trust relations with respect to other scopes**, which means the trustor has already established a trust relationship to the trustee but with respect to another situation. Depending on the similarity of this situation and the current situation, trust may be (partly) inferred.
- **Recommendations from well-known direct recommenders**, which means the opinion of other people, who are trusted by the trustor, is taken into account. This concept is known as transitivity and experiments show that this concept works well in several, however, not in all cases.
- **Reputation of the trustee,** where the relation of indirect recommenders to the trustee is considered, but there is no need for a direct trust relationship from the trustor to the trustee. Such recommendations are the most unreliable ones; however, if many opinions of such persons about the trustee are aggregated with respect to scopes, it is possible to infer a reasonable notion of trust as well.
- **Profiles of recommenders,** especially from indirect recommenders, may represent a valuable source of data, to decide if and how much someone's recommendation can be trusted.

4.4.6. Determining Trust by Monitoring and Analyzing Collaborations

Instead of manually rewarding individuals at the end of a collaboration case, we think automating this process by observing and analyzing collaboration scenarios may be an innovative new concept. This monitoring approach overcomes the dependencies on human feedback and their problems including low incentives for providing ratings, unfair ratings, quality variations of feedback over time, and discrimination. We think from logging and monitoring collaboration behaviour, such as who is communicating with whom, which people perform work together, who is contributing which resources and using which services etc., combined with profile data, such as competencies, experience, professions etc., we are able to get an objective and holistic view of a collaboration scenario and can determine the strength of collaboration links between each pair of participants, and ultimately a notion of trust.

Basically we distinguish two kinds of data to be used for determining trust, which is **static structural and profile data**, such as competencies and skills of a person, features of a service, or hierarchical structures and relationships, and **dynamic interaction data**, obtained from communications or service invocations. The first kind has to be manually entered in the system, and in COIN it is available in the centralized database. Structural profile data can be processed by applying filter rules and policies, while interaction data requires advanced mining techniques to find metrics and collaboration patterns on a higher level [DG6], [DH07], [TD08].

One crucial demand for determining trust relationships is obviously the availability of data from as many sources as possible. In the COIN scenario we have identified the following possibilities until now:

- **Centralized Database** contains information about formal competencies of companies and skills of individuals. Moreover, it contains information about virtual teams built during collaborations.
- **Communication Services** deliver valuable information about who communicated with whom how long and extensive respectively, and several more metrics depending on the type of communication channel (e-mail, IM, etc.).
- **Activity Service** stores structural information about tasks to perform, participating people, and services and resources used to reach a particular goal.
- **Document Management Service** logs who works on which documents
- **Service Invocation Logging** (needs an agreed Access Layer) can monitor who uses which services, how many errors occur during the usage etc.
- **Rewarding Services** from the COIN Baseline offer human feedback.

Based on further available services for the operational phase of virtual organizations (e.g. forum software for communication, wiki or blogs for knowledge sharing etc.), more sources of information can be utilized, to log and track somebody's working style.

4.4.7. Supported Use Cases in COIN

This subsection outlines the possibilities to utilize the concept of trust in COIN and how it will improve the overall COIN approach. Figure 15 depicts a complete VO lifecycle in the left side, which consists of VO preparation, formation, operation and dissolution. The coloured stack in the centre contains the most important concepts in the respective phases. We identified the following potentials to support COIN with the concept of trust, annotated on the right side of Figure 15:

Formation and Planning Phase: When virtual organizations or initial virtual teams are formed, previously successful combinations of organization and people respectively should be considered. Naturally it takes some time until people have adapted to each other's working style, learnt to collaborate efficiently and thus, to trust each other. Hence, there should be the possibility to 're-use' successful team compositions, which can be achieved by considering trust relationships.

Operational Phase: The primary support of our trust concept in COIN will be in the operational phase, during the execution of a pre-planned business opportunity. Because collaborations are rarely executed the way they have been planned, normally adaptations to the collaboration scenario have to be applied dynamically. If people get ill, machines get broken, or deadlines are missed due to other reasons, there may be the need for assigning more resources to a particular activity to cope with such problems. Trust relationships may help to find the most appropriate person or service for a particular situation. Furthermore, trust relationships may be analyzed to get a feeling about the working balance of existing teams.
Another use case in the operational phase is to consult experts for particular activities if needed. Such experts from a PVC can help regular activity members to perform their work and discuss complex topics. Of course such experts should be highly trusted by each activity participant with respect to the activity requirements.
During the operational phase the major part of data used to determine trust is produced, such as who works with whom performing which activities, using which resources and services.

Dissolution Phase: In the dissolution phase organizations and individuals get rewarded for their work within a VO before it is dissolved. Normally KPIs are calculated to determine the success of previous collaborations. We think we can support this process by offering data about trust evaluation as well, for instance the amount of activities somebody has been participating, the number of interactions with other people, the number of created artefacts etc.

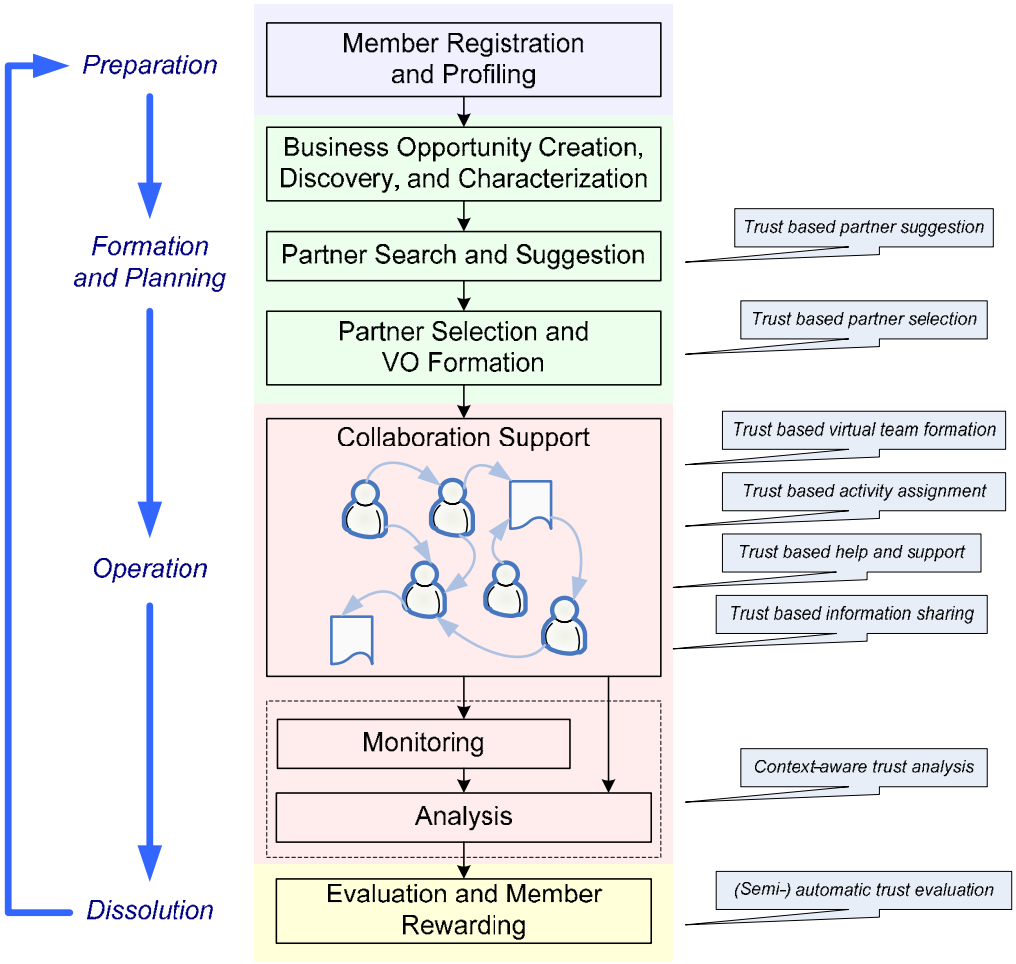

Figure 15: Usage of trust in COIN

5. Architectural Design

In this chapter we show, which components realize the aforementioned innovative concepts, where they are positioned in the overall architecture and how they are linked together. Furthermore, we outline how we connect new innovative services to the already established COIN Baseline and discuss the way to ensure an appropriate integration approach.

5.1. SaaS-based Architecture

Following the SaaS-U model and the generic sub-division in **Data Layer**, **Service Layer** and **Tools Layer** applied for the COIN Baseline services, we develop the architecture shown in Figure 16. It depicts the most important parts for innovative c-HI services and tools atop, as identified in the previous sections.

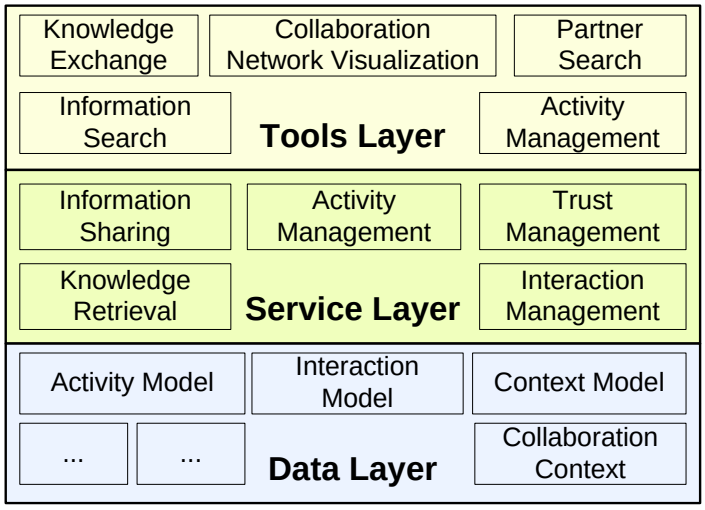

Figure 16: Architectural overview

The **Data Layer** is required to handle all types of artifacts during collaboration. This layer is used to manage, link and utilize any kind of data needed during collaboration processes, either physical entities (e.g., documents, rooms, technical equipment) or virtual ones (e.g., addresses, knowledge data). Sophisticated discovery and addressing mechanisms enable the search for and use of data across enterprise boundaries. In this layer, a critical issue is to design data structures for cross-enterprise context models, interaction models and advanced models for activity-centric collaboration which address the linkage among actors, activities, and resources.

The **Services Layer** contains supporting functionalities for finding and combining available basic services. This layer includes services to enable collaboration and compositions of these services, and typical SOA features such as lookup and data mapping. Composed services may consist of Web 2.0 technology (e.g. forum, wiki, file sharing) combined with service oriented technologies, and HPS. This layer includes services for handling the collaboration scenario such as managing activities performed by individuals and teams, relationships between actors, links to interaction models, connecting humans with utilized services and used, produced, and edited resources. In this layer, trust is determined with respect to collaboration context. Components of this layer, typically Web services, can be utilized by our own tools, and are a basis for tools from c-PD, c-PP and c-PM as well.

The **Tools Layer** contains components for the visualization and presentation of collaboration results to the end user within the COIN portal. Tools are built based on Web 2.0 technologies, such as widgets and mashup tools. Tools are intended to be used by end-users with different roles, utilizing features of entities on layers beneath, actually Web services, hiding their complexity and abstracting their usage. Various tools can be built for collaboration network visualization based on activity and interaction data, information sharing based on the collaboration network and context models, as well as help and response support to ask the right people with the right knowledge in particular situations for support.

5.2. Integration with COIN EC Baseline

Figure 17 describes the COIN Enterprise Collaboration Baseline which comprises various existing services to support collaboration among enterprises [D4.1.1]. The baseline provides fundamental functionalities for establishing and managing collaborations, such as business opportunity management, communication services, and collaboration rewarding.

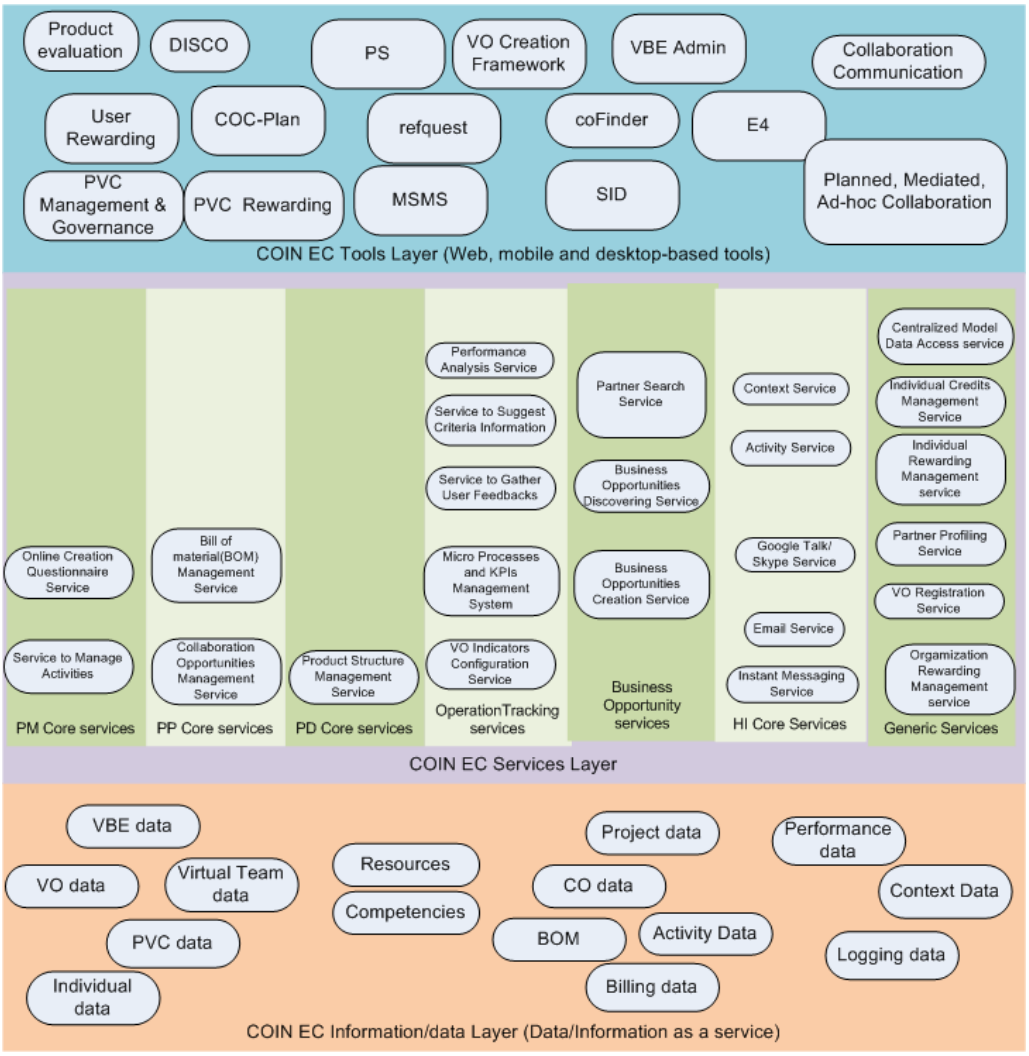

Figure 17: The COIN Enterprise Collaboration Baseline

We identified the lack of automatism in the existing enterprise collaboration baseline, which means many services rely on manual user input which is time-intensive and error prone. For

example the rewarding services are used to reward individuals and organizations after a successful collaboration. However, KPIs have to be calculated manually and then entered into the system via a predefined user interface mask. We think it is an innovative idea and a major research challenge to develop mechanisms for automatic KPI calculation based on analyzed user interactions. Thus we plan to provide automatically insightful information of human interactions and useful metrics to recommend the establishment and management of collaborations. On the one hand, information will be provided by our services to be utilized by tools from other work packages. On the other hand, various other services provide information which can be used to analyze human interactions, particularly services from production planning, project management or product development. Hence, we identify strong interdependencies between innovative c-HI services and other services/tools of COIN. The baseline services will be enhanced with the support of c-HI innovative services as well as the c-HI innovative services will exploit the baseline to support human interactions.

The COIN Baseline is used by c-HI services in the following way:

- **Baseline Communication Services** (such as Email, VoiceChat, Instant Message): provide basic facilities for communication. Furthermore, logging information will be used to determine human interaction metrics and to find out who communicated with whom, performing which activities in which projects and situations and how successful they are.
- The **Activity Service** is used in the operational phase to track the state of tasks and to link actors with services. Based on this information, statistic data obtained from the Activity Service will be used to determine human interaction metrics and trust.
- The **centralized database** and competencies model service will be used to obtain basic information about humans, teams and organizations, as well as virtual organizations. This information includes competencies, features, profiles, skills, previous successes, knowledge, and performance indicators.

Because human interactions are a fundamental aspect of every collaboration scenario, we plan our c-HI services to support services and tools of other work packages as well. At the time of writing, the c-PD, c-PM, c-PP services specifications are still under development, thus, synergies have to be found in the early future. We mention here some exemplary use cases for c-HI services:

- **Business Opportunity Service**: Finding, discovering and managing new business opportunities requires trusted relations between participating companies.
- **Partner Search and Selection**: Finding and choosing the right partner for a particular business opportunity or sub activity needs to consider relationship of partners due to previous collaborations, as well as taking the whole collaboration context into account.
- **KPI Management**: Key performance indicators are currently calculated and entered into the system by human users. We will investigate how we can support this process by automatically determine them and expose them for rewarding services.
- **Project Management Services**: A part of project management is the planning of work, which we understand to be modeled as activity flows. Which partners perform which activities most efficiently in which situations is not only depending on their formal competencies, but is highly influenced by social issues expressed as trust.

6. Innovative c-HI services

In this section, we outline the c-HI services that we foresee for COIN in order to support networks of enterprises.

6.1. End-User Requirements

The goal of this section is to introduce end-user requirements and how previously introduced concepts can support these requirements. We have identified and analyzed the following requirements as described by the end-users in deliverable [D6.1.1a]. In particular Table 1 is derived from c-HI requirement 25, Table 2 from c-HI requirement 26, Table 3 from c-HI requirement 27, and Table 4 from c-HI requirement 28.

Requirement	A visualization tool should be provided to the user for monitoring various aspects of the collaboration networks.
Description	To support this requirement, we will develop an innovative service that is able to utilize information captured by monitoring and analyzing interactions. From the users' point of view, the visualized information ranges from mechanical parts used in collaborations, actors (collaborators) involved in interactions, to information provided by project management services. However, visualization and sharing of such information raises fundamental trust issues (e.g., who can view information and to which level of detail). Trust models will help to make such decisions.

Table 1: Visualization capabilities

Requirement	Services and tools should be provided for sharing of processes and related information. Relevant information should be provided to support decision making support.
Description	We aim to support this requirement through document and context sharing techniques. From the c-HI support, processes descriptions can be enhanced context information and linked to human activities (for example, in which VO collaboration scenario a specific process such as a work breakdown structure is used). Not only novel context models are required, but also services and techniques supporting information gathering from various sources. In addition, policies restrict access to shared information (for example, with and cross-VO policies).

Table 2: Information sharing

Requirement	Discussion forums should be provided so that partners can share knowledge, can self-update competencies, find gaps and fill gaps.
Description	Automatic expert search capabilities should allow for knowledge sharing among humans through HPSs. Furthermore, knowledge sharing will follow different models, depending on the user's participation preferences. These knowledge and human capability sharing techniques will be enhanced by linking various

	information sources, for example, blogs or team Wikis, into a unified view.

Table 3: Enabling online discussions

Requirement	Provisioning of help and support functions with online and human response options should be supported.
Description	We can think to provide enhanced communication services together with context-awareness and mobile devices to support real time responses. However, for the future of networks of enterprises, it is important to find out the right person to respond to a request at the right time. It not only requires the system to utilize and link human knowledge but also the context in which collaborations take place.

Table 4: Online support provisioning

6.2. Partner Use Cases

Besides COIN's generic innovation requirements and particular end-user requirements mentioned in the last section, we base the development of our service specifications on available concrete use-cases, provided by industrial COIN partners.

Business use cases studied from the **Andalusian Aeronautic Cluster** [BUC1]**:** This cluster consists of a set of companies, which build virtual organizations for particular business opportunities. The first use case is the "**Data sharing, rewarding & control of cluster competences"** which is related to the cluster management. It demonstrates the need of sharing data during collaborations. Cluster members collect their own data with their ERP system and upload their data into the common repository which is accessed from a portal.
One major challenge is to provide techniques to manage and map dynamic competences (which can be profiles of provided technologies, finance, or production capacity) associated with enterprises, teams and individual humans, together with the network of collaborators. When imagining beyond the requirement, we could think that this collaboration network should be enriched with trustworthy information which is automatically gathered by observing collaborations. Furthermore, activities and processes among cluster members can be shared.

Second, drawn from the use case "**Search for VO partners and evaluation",** when an interesting Business Opportunity (BO) is found, the cluster will be searched for suitable partners to set up a VO. This search is based on competences as well as the availability of partners. The search can also be extended to other clusters, and furthermore, the value of this search operation can be enhanced, by considering results from trust analysis. To search a partner, the competences required for the BO are defined and potential partners from the cluster or professional networks (in the case of engineering projects) are searched. The evaluation of partners relies on various types of information, such as availability, trust, and capacity of potential partners, by using common tools, such as telephone, e-mail or personal visits.
With respect to human interactions, we need a collaboration network covering human interactions within the cluster, built by monitoring of collaborations. Furthermore, insightful information, such as trust and reputation, is particularly important for partner search. By considering interaction information, we could enhance the outcome of the search process.

However, we must be able to provide useful indicators based on different collaboration contexts since a BO is based on different contexts.

The third motivating scenario is studied from the business use case **"Product Design, Engineering and manufacturing"** in which collaborative activities shared by multiple teams are conducted to ensure the success of product manufacturing. In this business use case, typically each enterprise uses its own design and manufacturing system, and teams use e-mails and telephone as common communication tools. However, current solutions are not sufficient and the cluster needs real time capacity and production planning which allow distributed design and customer involvement, besides other features. Furthermore, during the design, specific requirements on human capabilities have to be covered, requiring the search for experts.
With respect to human interaction, this use case brings several challenges to how humans (whether they are designers or customers) can be integrated into the product design. Not only we need a mechanism to foster human participation but to search humans with needed capabilities on demand. We need to allow humans to share their knowledge which can be searched and utilized in SOA environments.

Finally, the scenario from the business case "**Interest representation"** [BUC2] introduced by IND Ltd which is part of Hungarian Association of IT Companies (IVSZ), is analyzed. This company offers representation of interests, service provision, networking (connecting different players, building trust), and communication. In the business use case "**Interest representation",** the company has active contacts with ministries and government organizations and works on workgroup recommendations that will be delivered to the appropriate bodies. In this case, the government organization requests the workgroup to review a working document with a short deadline. In response to the request, the group leader will distribute the document to task leaders who pass it to members via emails or a common portal. Comments and recommendations from members will be collected by task leaders who can organize meetings and summarize the comments and recommendations.
With respect to human interactions, this use case demonstrates the need for a dynamic mechanism to allow humans (e.g., team leaders, team members and external experts) to participate in the workgroup. Not only humans should be able to work on comments and recommendations at anytime, in any place and with any device but more importantly humans capabilities should be exposed and searched so that expertises can be easily utilized.

6.3. Overview and Description of c-HI Services

In the following section we describe how our innovative c-HI concepts can be used to support end-user requirements. Figure 18 provides a short overview about how these requirements for c-HI services [D6.1.1a] are supported by tools we plan to develop, and which services and concepts these tools utilize in the back-end.

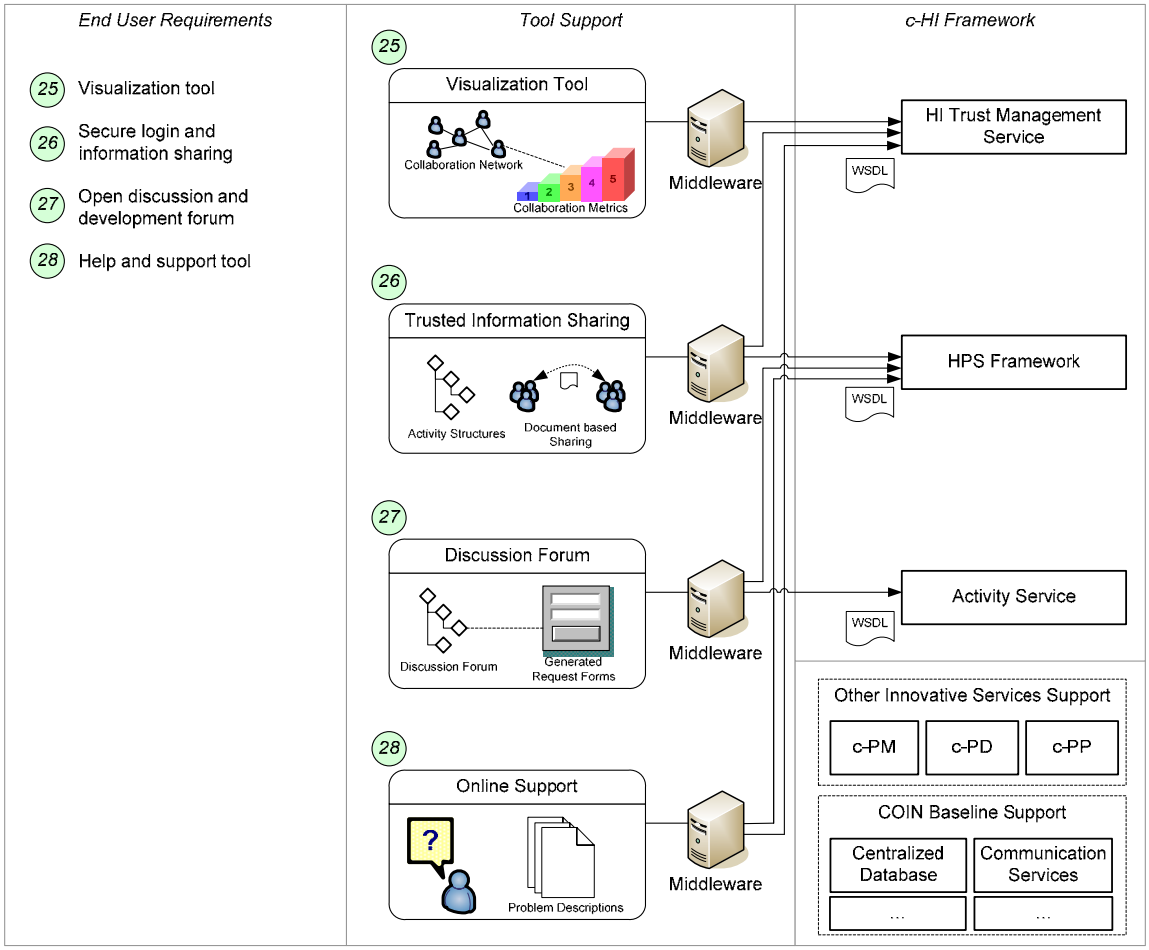

Figure 18: Overview of c-HI services and tools

6.3.1. Mapping of End-User Requirements to Tools

The four end-user requirements from [D6.1.1a], depicted on the left side of Figure 18 are mapped to tools; we intend to provide for COIN. These tools utilize various frameworks in the back-end, realizing the earlier presented concepts, such as human provided services or trust management. In the following section we present the main features of the planned end-user tools.

6.3.1.1 Visualization Tool

The Visualization tool, supported by the HI Trust Management Service aims at providing information about collaboration networks such as actors and their interactions. The utilized HI Trust Management service will need to access not only monitoring data, e.g., whether collaboration between humans is successful in terms of finished tasks or not, but also structured data about activities and user profiles (e.g., competencies).

These data will be obtained from the COIN EC Baseline services as well as innovative services. Therefore, this service will provide insightful information not only to the end-user but also to other services:

- Trust obtained through analysis can be obtained by other services to support trust-based partner selections in the formation phase of a VO
- Service or team member selection in the Project Management Service
- Source for the KPI management

6.3.1.2 Trusted Information Sharing

This tool supports sharing of business-related information, such as processes and activities. It establishes links between actors and their shared resources, such as documents and further project artifacts, with respect to collaboration contexts. Furthermore, sharing policies are bound to collaboration contexts in networks of enterprises. An innovation of this service is to provide trustworthy information about processes.
The Trusted Information Sharing tool will rely on some existing document repositories to physically store documents. It will utilize the COIN EC Baseline and the COIN Generic Platform services to ensure proper access control.

6.3.1.3 Discussion Forum

The Discussion Forum tool will utilize the HPS middleware to support users to expose their capabilities via Web services. Various COIN EC Baseline services will be utilized, such as KPI Management and Competency Management Services, to support the mapping from knowledge requirements to human capabilities.
In particular, this service supports users to share their capabilities as HPSs by linking their services into existing Web 2.0 platforms, for example, blogging tools and online discussion forums. Hence, HPSs can be linked to posts or blogs. However, the novelty of this approach is that shared knowledge and human capabilities can be automatically searched, and humans can be integrated into Web 2.0 platforms in a seamless ***service-oriented manner***. We plan to investigate how concepts such as SIOC[7] and FOAF can be used in combination with HPS.

6.3.1.4 Online Support

Finding the right person based on situational awareness is an important feature that has not been well addressed in networks of enterprises by means of ICT facilities. Right partners can be determined based on current VO lifecycle phase, for example, VO formation requires senior experts experienced in strategic planning.
The Online Support tool will utilize c-HI services, such as the Trust Management Service, and other EC innovative services, such as Product Development Services, to obtain information about the situation and available resources. Based on context, the Online Support tool can route requests to the best available expert considering given priority constraints.
On the one hand, it utilizes common Communication Services to support online communication and coordination based on the vision "*anytime, anyplace and with any device*". On the other hand, it can be integrated with HPS to supports human interactions in all VO lifecycle phases.

6.3.2. Use Case of Trusted Context-aware Online Discussion

The following use case illustrates how previously introduced concepts and technologies such as HPS can be used to support COIN requirements. In this specific use case, we focus on supporting **online discussion forums**. The use case is shown in Figure 19 with a detailed discussion following below.

[7] SIOC project home: http://sioc-project.org/

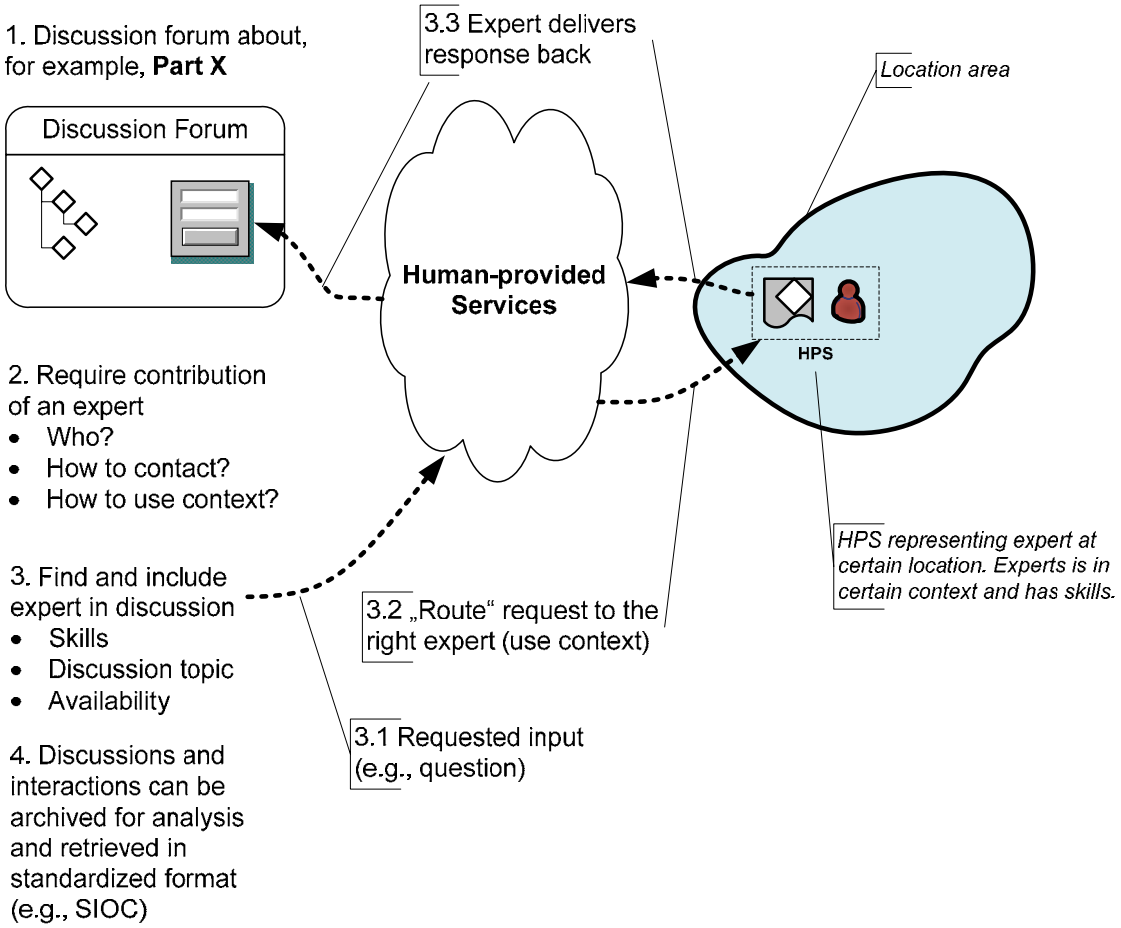

Figure 19: Example use case of trusted, context-aware, online discussion

We assume that a set of HPSs already exist and users provide such services based on their expertise. In particular, an HPS is depicted by the compound symbol (right hand side). HPSs can be discovered using context information. For example, in this case we assume that context comprises information about the user's location. Also, we depict a certain *location area* as "sphere".

Based on these assumptions we elaborate on four essential steps:

1. Discussion forum: users can start discussion about various problems and issues using a discussion forum tool. Discussions can be structured in a hierarchical (threaded) manner.
2. At some point we assume that input of an expert is required who can help in solving the discussed problem. Basic questions include:
   - Who is the best available expert?
   - How to contact the expert? For example, what is the best communication channel?
   - How to use context? Context in this scenario includes location area and availability of experts.
3. Find and include experts in discussions. Experts can be consulted by sending "requests" to their respective services. Notice, requests are basically documents containing information the expert needs to solve a given problem.
   3.1. Requested input is provided as form
   3.2. The request is sent toward the HPS framework, which automatically routes the request to the best available HPS

3.3. The expert reviews the request (using his/her device at hand) The response is delivered back to the discussion form

4. All discussion including HPS interactions are saved for further analysis. For example, such interactions can be used to establish trust, etc.

7. Related Work

In the course of the EU FP6[8] program, various projects have been devoted to support collaborations among people, teams, or companies, such as inContext[9], ECOSPACE[10], and ECOLEAD[11]. Based on the work performed for these projects, the goal of COIN is to harmonize the results and provide one unified supporting platform for enterprise collaboration and integration. However distinguished results have been achieved, there is still much work left, for c-HI primarily in the area of managing and sharing processes, knowledge, and documents in complex and highly dynamic networks of enterprises.

Currently available concepts for collaborative working environments, such as described in [STD08c] are not sufficient in COINs collaboration environment. Some projects, e.g., Myexperiment[12], support sharing workflows, however, not suitable for networks of enterprises, because of the lack of advanced collaboration context models.

Based on the identified shortcomings of existing solutions, and the innovation requirements of COIN, we aim at providing services implementing the proposed concepts in this document.

Activity-centric Collaboration: Dustdar [Dus04] introduced Caramba, which is capable of supporting ad-hoc collaboration in virtual teams. Caramba organizes work items of individuals as activities that can be used to mange collaboration. For example, one can see the status of an activity, who contributed to an activity, documents created within a particular activity, etc. Based on log analysis, human interaction patterns can be extracted [DH07]. Harrison, Cozzi, and Moran [HCM05] report on studies regarding activities in various work settings. Their field studies identify patterns of complex business activities, which are then used to derive relationships and activity patterns. Moran [Mor05] presents activities as a unified “Metamodel” along with metadata. Moody et al. [MGM+06] discuss activity-centred computing, and activity patterns. The potential impact of activity centric collaboration is highlighted with special focus on the value to individuals, teams, and enterprises.
Tasks and activities are at the centre of attention of Tripathi et al. [TKA05], Ahn et al. [ALC+05], and McCrickard et al. [MCS+03]. Studies on distributed teams can be grouped according to performance [SC05] leadership [ZFT05], [SV06] conflicts [HM05] interaction [BPW04], [CK05], [PD05], and activities [Guy05]. A comprehensive review of such research can be found in [PPO04].

Context-aware Computing: For the last years, context has been at the center of many research efforts. As a multi disciplinary domain, multiple definitions exist, most of them fitting just a certain focus. In the domain of computer science the definition given by Dey and Abowd [DA99] is amongst the most widely adopted ones. Bradley and Dunlop [BD05] have developed a multidisciplinary context model. To get an overview, Baldauf et al. [BDR06] provide a survey on context models, techniques, frameworks and applications. Amongst the techniques to facilitate context use are Dey et al. [DHB+04] “programming by demonstration” approach and Loke’s [Lok06] context aware artefacts.

[8] http://cordis.europa.eu/fp6
[9] http://www.in-context.eu
[10] http://www.ip-ecospace.org
[11] http://ecolead.vtt.fi
[12] http://www.myexperiment.org

Trust in Collaborative Environments: Marsh defined first 1994 [Mar94] trust as a computational concept, a basic definition of trust, the factors it relies on and first concepts to model trust. Since his work several further definitions of and models for trust have been proposed. Some surveys of trust in computer science have been performed, including Artz and Gil [AG07], Jøsang et al. [JIB07], and Ruohomaa and Kutvonen [RK05], which outline common concepts of trust, clarify the terminology and show the most popular trust models. From the large amount of different trust definitions, such as [ORM+05], [GS00], [Mui02], [Mc96], [Gam90], we adopt definitions from Mui [Mui02] and Grandison and Sloman [GS00] which fit best to our collaboration environment.

There are many reputation models from the SOA domain, such as Li et al. [LSY07], Maximilien and Singh [MS04], but they are dedicated to Web services only, thus are mostly not applicable in collaboration environments.

In contrast to reputation systems, in the domain of social network analysis, e.g., [WF94], the relationships between single entities are highly researched. From this area we get valuable input about the composition of typical user communities, such as from Gomez et al. [GKL08]. Experimental case studies, including Massa and Avesani [MA05], offer insights in human collaboration behaviour, and enables to define requirements for our trust model beneath innovative services.

The aim of trust models is to abstract the fuzzy notion of trust and to build a mathematical model to enable systematic trust calculation and analysis between any entities. There are several papers dealing with the definition and implementation of trust models in general, such as Ramchurn et al. [RJS+04], and Huynh et al. [HJS06], or focusing particular aspects such as propagation [GKR+04], [QHC07] or mobility [SDB04].

The concept of trust has been already identified to be vital in collaborative environment, and applied with respect to the concept of virtual organizations by e.g., Kerschbaum et al. [KHK+06] and Zuo et al. [ZP05].

8. Conclusion and Future Plan

In this deliverable, we have covered COIN's innovation requirements with respect to human interaction support, such as enabling flexible collaborations, network based information sharing, modeling and considering context, and creating participative social software. We introduced concepts such as collaboration context established upon the notion of activities and trust models targeting novel forms of cross-enterprise collaboration.

This deliverable is the first step towards the support of human interactions in Enterprise Collaboration in COIN. The scope of this deliverable was to introduce various concepts from a high level perspective. The next version of this deliverable will focus on the software design and a more detailed specification of innovative c-HI.

In particular, we plan to define an advanced **c-HI model of activity-centric collaboration**. The current model presented in this deliverable manages information about actors working jointly on tasks, linking together humans, services, and resources. However, trust concepts have great impact on how activities are modeled and executed, for example, degree of trust between actors participating in the scope of an activity, which we have not yet considered in the current model. Furthermore, we are working towards an enhanced **c-HI context model** capturing requirements targeted in COIN scenarios, for example, which dimensions need to be modeled as context including scope of work and affiliation, as well as requirements found in various COIN VO lifecycle phases.

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