

# **“Future and Emerging Technologies and Paradigms for Collaborative Working Environments”**

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## Preface

On 30-31 May 2006, the New Working Environments Unit of the Directorate General information Society and Media of the European Commission organised the 5<sup>th</sup> Expert group meeting where recognised experts in the field discussed Future and Emerging Technologies and Paradigms that will affect the R&D agenda in the Collaborative Working Environments (CWE) area in FP7 (2007-2013). The workshop gathered members of the Collaboration@work Experts Group representing academia and research departments within IT industry.

This publication encompasses the findings coming out of the workshop summarising the revised vision of the target CE2020, expected impact, **new three Building Blocks, new list of 5 emerging paradigms** and updated research challenges brought forward by the experts.

### **Main conclusions**

#### Target outcome

In 2020 Collaborative Working Environments will be based on **collaborative systems** including both general collaborative infrastructures and specific applications for supporting **human-centric collaboration**. **Collaborative infrastructures** will offer seamlessly integrated context-aware flexible support for distributed collaboration among individuals and will draw on service-oriented **reference models** for massive semantic collaboration. Collaborative infrastructures will provide pro-active support for pervasive human collaboration within their own organisations, with other organisations and with virtual communities of experts and of practice. Collaborative infrastructure will provide system components that comply with the Service Oriented Architectures allowing specific applications for **group-driven composition of systems components** to support synchronous and asynchronous teamwork freeing users from routine to focus on creativity with an effective use of distributed knowledge and competences. **Converged networks and services**, context modelling and reasoning, utility-like ICT, high-level middleware (**upperware**) and **P2P** infrastructures will be part of the collaborative infrastructure needed for Collaborative systems for **pervasive collaboration** that offers enhanced knowledge sharing mechanisms, better decision making process and less burdensome group processes support in distributed, global networks of collaborators.

#### Expected impact

Collaborative Working Environments 2020 will create the following impact:

- at organisation level, it will enable a faster time to market, increased business model innovation, better consistency of cross domain processes, and improved flexibility and lead time in global product development;
- at team level, it will lessen misunderstandings, will increase re-use of shared information and knowledge, and will make more efficient task management and allocation through competence networks;
- at individual level, it will boost creativity by reducing routine work, will improve use of idle time through pervasive collaboration services and allow natural human interactions within a group.

#### Building Blocks **NEW!!**

To achieve the stated vision of CWE in 2020, several RTD challenges have to be addressed, and the Emerging paradigms have to be considered. From a practical point of view, these RTD challenges can be translated into three 'operative' Building Blocks (BBs) (page 22):

BB1: Collaborative infrastructures, aiming to foster value creation, exploitation and preservation and to stimulate creativity;

BB2: Reference models and patterns for CWE;

BB3: New methods and concepts of work in various collaboration environments.

Emerging paradigms NEW!!

Five contemporary paradigms have been discussed, considering their place and scope and detailing issues and approaches related to each paradigm. The new paradigms considered were:

- **Web 2.0.** Move from the individual level of Web 2.0 to company and group level.
- **Serious games** for learning and to perform work.
- **C-pod** (collaboration-supporting-Pod). Consider C-Pod as a capability of a future super-device rather than as yet another device to be worn by the user
- **C-etiquette.** The creation of a set of social processes, models and methods designed to complement any technical solutions is a difficult research challenge.
- **Cooperativity.** Cooperativity may be formulated as the degree to which a CWE offers user-friendly and effective support for the collaborative process within a group.

Research challenges. Updated from previous workshops

The changes to the RTD challenges (page 11) identified in previous meetings were:

- To make collaborative working environments suitable for non-technical users, making sure that people who are not IT specialists can relate to and control the ways in which software and hardware support group collaboration.
- On the other end of the IT competence spectrum, we should extend the reach of CWE to the research and advanced technical development community itself, thus bringing the outcomes of using tools and environments closer to the researchers who conceptualise, design, implement and study these tools and environments.
- In terms of granularity of context, it was considered of value to investigate differences between global and regional context in terms of collaboration support needs and the context of using collaborative tools.

The updated list of RTD challenges (which are mapped into the 3 Building blocks) is:

(1) <b>Cooperativity</b> in future collaborative tools and devices;	(7) <b>Integration</b> between synchronous and asynchronous work.
(2) <b>High-level collaboration middleware (E-collaboration UpperWare).</b>	(8) Support for <b>virtual communities</b> of practice and of interest.
(3) <b>Modelling of collaborative context.</b>	(9) <b>Service composition and integration.</b>
(4) Activity-oriented context-aware <b>collaboration features provided by the collaborative infrastructure</b> supporting human interactions.	(10) <b>Distributed Management and reasoning on context knowledge.</b>
(5) Proactive <b>collaboration aware artefacts</b> and.	(11) <b>Reference model.</b>
(6) <b>Pervasive collaboration support.</b>	(12) <b>Heterogeneous devices with embedded collaboration capabilities (c-pod).</b>

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## **Abbreviations**

BB	Building Block
BPEL	Business Process Execution Language
CWE	Collaborative Working Environment
e.g.	<i>exempli gratia</i> = for example
EC	European Commission
EE	Extended Enterprise
etc.	<i>et cetera</i>
EU	European Union
GUI	Graphical User Interface
HTTP	Hypertext Transfer Protocol
i.e.	<i>id est</i> = that is to say
ICT	Information and Communication Technology
IP	Internet Protocol
IPR	Intellectual Property Rights
ISO	International Organization for Standardization
IST	Information Society Technology
IT	Information Technology
KM	Knowledge Management
P2P	Peer to Peer
R&D	Research and Development
RTD	Research and Technological Development
SME	Small and Medium Enterprise
SOA	Service Oriented Architecture
SotA	State-of-the-Art
w.r.t.	With respect to
XML	Extensible Markup Language

## Summary

This report highlights findings on some of the most significant **Future and Emerging Technologies and Paradigms** for Collaborative Working Environments (CWE) for Europe. The vision, some key research challenges and three Building Blocks are also discussed. The arguments are based on the findings of the 5<sup>th</sup> meeting of the Experts Group on Collaborative Working Environments (CWE) set up by the European Commission (EC), which met on 30 and 31 May 2006 in Brussels to discuss the state of the art and emerging paradigms that will impact CWE technologies relevant for the 7<sup>th</sup> Framework (2007 – 2013). The work of the 5<sup>th</sup> Expert Group meeting strongly built upon the previous consultation activities: In January, February, March and May 2006, New Working Environments Unit of the Directorate General Information Society and Media of the European Commission organised 5 workshops (11 working days) and the large CWE06 conference where recognised experts in the field discussed the most outstanding research themes that will affect the R&D agenda in the Collaborative Environments (CE) area in FP7 (2007-2013).

The work of the 5<sup>th</sup> Experts Group Meeting included:

- update of the Vision of Future Collaborative Working Environments 2020, re-considering their scope and priorities in the light of new technological and societal developments;
- update of the previously identified 7 RTD challenges according to the new vision and recent research and technology developments;
- in-depth analysis of the place and focus of several Future and Emerging Technologies and Paradigms: WEB2.0, Serious Games, c-pod, c-etiquette, Cooperativity;
- definition of three Building Blocks which represent a mapping of the identified RTD challenges in operative RTD tasks.

The meeting concluded with the presentation of the key findings to Mr. Bror Salmelin, Head of Unit, DG Information Society and Media, European Commission; and Mr. Aymard de Touzalin, assistant to the director and responsible for PP7 Content Co-ordinator; and discussion on key issues.

It is concluded that the further work should focus upon elaboration of the three Building Blocks, prioritising the challenges and identification of possible approaches to these RTD tasks. It is intend to involve wider industrial and RTD communities in these tasks. During the meeting 3 working groups were created. Each working group will be responsible to organise a workshop on each of the Building Blocks; taking place on 10, 11, 12 October 2006. The objective is to continue work on sharpening CWE research domain.

### **Workshop Organisation**

The workshop was organised over two days. The first day focussed on the update of the Vision of Future Collaborative Working Environments and of the key RTD challenges. The five Future and Emerging technologies and Paradigms challenges were specifically considered. The second day was dedicated to the definition of the three Building Blocks.

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## 1. INTRODUCTION

Research on Collaborative Working Environments (CWE) should focus on seamlessly integrated activity-oriented, context-aware **collaborative infrastructures**, and on **reference models** for semantic collaborative working supporting human interactions to enable productivity and innovation through empowered and motivated people, to collaborate within their own organisations (distributed across time-zones and different spaces), with other organisations (caring about IPR issues) and with virtual communities of experts and of practice.

Therefore specific research is needed on group-centric CWE technologies, tools and methods to motivate people through group-friendly **collaboration tools** that support synchronous and asynchronous teamwork freeing employees from routine to focus on creativity with an effective use of distributed knowledge and competences. Explicit challenges also arise from the need to empower people to work both in unstructured teams and in well-defined and stable settings through CWE **reference models** for seamlessly integrated activity-oriented, context-aware collaboration functions that provide enhanced knowledge sharing mechanisms, better decision making process and less burdensome group processes support.

New CWEs will **impact** at organisation level with a faster time to market, increased business model innovation, better consistency of cross domain processes, and improved flexibility and lead time in global product development. Besides, at team level, it will lessen misunderstandings, will increase re-use of shared information and knowledge, and will make more efficient task management and allocation through competence networks. Finally, at individual level, it will boost creativity through the reduction of routine work, will improve use of idle time through pervasive collaboration features and allow natural human interactions within a group.

This report is structured as follows. First, the vision for the year 2020 in respect to CWEs is revisited. The key RTD challenges identified during the previous Expert meetings and within the FP7 consultation process were revisited and updated (Section 3). Following this, five Future and Emerging technologies and Paradigms were specifically analysed (Section 4). Finally, section 5 is dedicated to the definition of the so-called three Building Blocks for the further collaborative working environments.

## 2. VISION 2020 – FUTURE COLLABORATIVE WORKING ENVIRONMENTS – UPDATE

The Vision 2020 was revisited and updated. The updated vision is:

### **Vision 2020:**

*Enabling Productivity and Innovation through empowering and motivating people using technology to work together by connecting systems, services and devices.*

### **Technological Vision 2020:**

*In 2020, Collaborative Working Environments will offer a set of **ubiquitous** hardware and software systems, composed of resources delivering a new blend of activity-oriented, context-aware flexible **system components** providing **pro-active** support for dynamic patterns of collaborative interactions between humans, systems, machines and devices.*

Modifications from previous vision:

The suggestions for change work towards more systemic view of the focus of research effort, and to thus include collaborative applications and environments rather than just the underlying infrastructure.

The focus of technology is explicitly included in this new version of the Vision. The Technological Vision is elaborated as addressing the collaborative interactions between humans, systems, machines and devices.

### 3. RTD CHALLENGES - UPDATE

- (1) **Cooperativity** of a Collaborative Environment. With cooperativity we denote the usability of a CWE for a group and a collaborative process. *The challenge would be to both promote cooperativity in regards to existing tool use, and to embed cooperativity-supporting features in future collaborative tools and devices;*
- (2) **High-level collaboration middleware (E-collaboration UpperWare)**. Emerging new forms of dynamic and agile collaboration pose requirements that current collaborative infrastructures do not satisfy. New architectures and technologies for (mobile) collaborative infrastructures are required. The generic model of collaborative infrastructure is mapped to the Services. To alleviate the tasks of the developers, the basic collaborative functions, Locking, Presentation Control, User Presence Management, Organisation Management and Communication Control are gathered into a Collaborative infrastructure and made available to the applications. A collaborative service can be built by composing or by orchestrating the (distributed) collaborative functions provided by the collaborative infrastructure. Current Middleware definition as a “glue” to patch machines and their software functions together is not anymore appropriate to distinguish this new conceptual approach. One may identify this as new category of Software generic infrastructure called “UpperWare”. It becomes thus clear that the generation of such a E-collaboration infrastructure will ease and greatly facilitate the generation of concrete and easy to share developments. (like has been high level graphical High level O/S with respect to DOS O/S).
- (3) **Modelling of collaborative context**. Collaborative infrastructures offer their functions for a large number of users and deal with massive numbers of contextual information. A context model, to represent various contextual data with a well-defined meaning acquired from different user interactions and services from a basis for higher level tasks such as context learning and coupling. Context management includes relevant analysis and evaluation of context representation models for dynamic collaborative environments. Various approaches are available for modelling and representing contextual knowledge and user profile information required for collaborative systems. Such approaches range from simple key-value models, logic-based models to ontology-based models. Different reasoning techniques (e.g., logic based or probabilistic reasoning) should be increasingly investigated to infer new contextual knowledge from existing contextual information. Additionally, transformation models can be used to capture the different team configurations and team members changing different teams. From a user-oriented view this will result in a reduction of information and cooperation overload to reduce stress However, achieving this requires *research in the ability to present information with multiple methods and representations*, and to create audience-specific views based on the different roles and IPR interests involved in a collaboration process.

- (4) Activity-oriented context-aware **collaboration system components** supporting human interactions. Today's work is characterized by multi-tasking and many interruptions. *This requires systems that allow users to develop and enhance their own collaborative environments, thus blurring the boundary between designing and using, and enable rapid context switching and that provide immediate awareness on the status of the collaborative process.*
- (5) Proactive **collaboration aware artefacts** and objects are needed to transform static data so that the entire life cycle of shared artefacts is supported.
- (6) Support of **pervasive collaboration**. This requires research in other media than the PC-based desktop: ePaper, augmented and mixed realities, ubiquitous and ambient technologies. Special focus must be on the use of these technologies in a collaborative setting and their integration in a collaborative environment.
- (7) **Integration** between synchronous and asynchronous work. Current systems do not integrate both working patterns, but focus on one or the other. Therefore research is needed in environments allowing synchronous & asynchronous cross domain communication/collaboration.
- (8) Support for **virtual communities** of practice and of interest. Communities have emerged as one of the primary CWEs within which knowledge activities are framed and enabled within and across organisational social boundaries. Specific methods and tools are needed for the creation, persistence and effective action within communities.
- (9) **Service composition and integration**. The system components provided by the collaborative infrastructures are offered as services to the developer level. Service composition deals with the process of aggregation and provisioning of value added services. Composition occurs on many levels, starting from design-time to run-time and all potential phases in between. Service composition encompasses necessary roles and functionality for the aggregation of multiple services into a single composite service. Resulting composite services may be used by service aggregators as basic services in further service compositions or may be offered as complete applications/solutions to service clients.
- (10) **Distributed Management and reasoning on context knowledge**. Since context information can be aggregated from many sources such as sensors, software, human interactions etc., it becomes increasingly a challenge to build a highly distributed context management environment, taking all relevant sources into account.
- (11) **Reference architecture**. Building scaleable collaborative working environments includes a multitude of architectural styles such as Peer-to-Peer and Client-Server. It is of paramount importance to establish a blueprint for future service-oriented collaborative services and their architectures. This challenge is inline with activities required in the "UpperWare" mentioned above. Next to a fundamental architectural blueprint (reference architecture) it seems useful to include vertical "plug-ins" as extensions for various often changing, industrial requirements which are not an integral part of the fundamental layer.
- (12) **Heterogeneous devices with embedded collaboration capabilities (c-pod)**. Collaborative services need to be instantiated (invoked) on a multitude of devices ranging from desktops to lightweight SmartPhones and PDAs. This challenges the software architecture and service container model of today's middleware and development approaches to some extent. Therefore, it is important to analyze the needs and requirements of mobile devices with the goal to include them into collaborative mobile scenarios being able to offer services as well.

### Changes from previous work:

Discussions and proposed changes were again informed by the drive towards increasing the scope and outreach of the effort in collaborative working environments. For example, attention was paid to making collaborative working environments suitable for non-technical users, making sure that people who are not IT specialists can relate to and control the ways in which software and hardware support group collaboration.

On the other end of the IT competence spectrum, we should extend the reach of CWE to the research and advanced technical development community itself, thus bringing the outcomes of using tools and environments closer to the researchers who conceptualise, design, implement and study these tools and environments.

In terms of granularity of context, it was considered of value to investigate differences between global and regional context in terms of collaboration support needs and the context of using collaborative tools.

## **4. ANALYSIS OF FIVE FUTURE AND EMERGING TECHNOLOGIES AND PARADIGMS**

The group then analysed five contemporary paradigms in turn, considering their place and scope and detailing issues and approaches related to each paradigm.

### **4.1. Web 2.0**

#### *4.1.1. The vision now*

A set of foundational technologies for web-based collaboration (AJAX, REST, RoR, etc.) exists at present, such as in Flickr and Technorating, folksonomy, social networks, tagging, Google, MySpace ... The direction of development would be to start from these technologies and develop them into **fully-fledged technology platforms** which interoperate to support distributed collaboration activities.

Whilst doing this, the granularity of abstraction would grow **from the level of an individual person to the levels of teams and organisations**. At present service composition is considered at individual level, the techniques and mechanisms for this would have to be expanded to the other levels.

The **result** will be the emergence of a distributed information space, where machines can support humans in selecting the right information. This would also empower users in their capacity as knowledge workers and increase the scope and effectiveness of e-collaboration.

#### *4.1.2. Research challenges and issues*

We need to define the scope of collaboration interests within the set of Web2.0 technologies, thus charting the important things we have to be focused on.

The majority of mechanisms for **streaming media and content** are not yet compatible with the current vision of Web 2.0, since the content of these streams is currently outside of the scope of existing search engines.

Related to this is the issue of **ownership**, this could be seen as vested in a community, which may eventually replace the publisher. It is however important to provide substitute for the quality indicators associated with the publisher-based model.

“**Google Suggest**” is an example of using ICT to help the individual to find and filter information. This may grow into innovative use of communities to reduce the search space.

#### *4.1.3. Looking to the future – what is beyond Web 2.0 (Web 3.0)*

We expect that future developments would continue the move from the service composition at individual level of Web 2.0 to company and group level (thus moving from ‘mySpace’ to “mySME”). The ideas behind Web 2.0 will seek applications outside of individuals and small groups to organisations and enterprises.

It is also likely that machines will be included as a part of your extended information and collaboration network, and that collaboration will take place on a **massive scale and global** geographical sense.

The latter development may challenge the affinity of people to countries since they would have closer interactions within, and hence affiliation with their communities. Governments will have to consider possible strategies of working in such a context.

## **4.2. Serious games**

### *4.2.1. Scope and relevance to CWE*

Serious games are not games during which are not allowed to have a laugh, instead the idea is to use the **motivational aspects** of games as a fun- and competition-focused activity for serious and useful purposes.

The target of serious games can be on

- (a) *learning* how to do new things using customised learning strategies, relying on games to introduce new concepts, skills, and social attitudes, and to
- (b) use serious games **to perform work** or work-related task with better efficiency and efficacy.

Example of the latter is the **ESP Game**, where competitive game is used to tag pictures with classifying meta-data for the purposes of the Semantic Web. “Pick-a-boo” is the most-recent extension, which is also used to identify important areas (parts) of the pictures.

Two other examples, oriented to children and learning skills, are O-GAME and Neopets.

### *4.2.2. Research challenges of serious games*

- (a) Devise gaming models and methodologies to increase motivation and enhance outcomes;
- (b) Provide mechanisms which **create a sense of community** by interconnecting people and allowing them to share experiences from the learning environment;
- (c) Study motivation and learning by exploration strategies in games and generate models and conclusions which are transferable to the serious games domain. This may happen at two stages:
  - a. Easily transferable elements such as user interfaces;
  - b. Elements which would require further work before they can be transferred, such as **advanced interaction within collaborative processes**.

The processes of collaboration can be seen as analogous to the traces of action in a game, and following collaboration norms and rules can be facilitated by the same mechanisms which enforce the rules of the game.

### **4.3. C-Pod (collaboration-supporting-Pod)**

#### *4.3.1. Would there be a C-Pod?*

A single-purpose devices such as iPods and Blackberry's have provided surprisingly popular with users, often creating strong branding ensuring customer loyalty even after the appearance of better competitive products.

The scope of activities involved in collaboration, however, is substantially wider than the scope of these two examples, which support single-focus activities such as listening to music or working with e-mail. This suggests that collaboration would be better supported by a multi-purpose device, such as a "grown-up" PDA or smart mobile phone.

**Convergence of hardware capabilities**, and the need to avoid cluttering the user with too many gadgets, also invites us to consider C-Pod as a capability of a future super-device rather than as yet another device to be worn by the user

The search for ways in which to transfer the popularity of these two devices to supporting collaboration suggests that one useful feature which can be transferred is the ability of these devices to carry with them the context of individual activity, such as the music library of an individual or the e-mail inbox folder and settings of an office worker. Perhaps then a **Context-Pod**, which carries with it the identity and collaboration preferences of the user will be a more likely "C"-Pod solution instead of the **Collaboration(-supporting)-Pod**.

#### *4.3.2. Usage case for C-pod*

A C-Pod would go beyond message-based primitives, and will package them in a **problem-specific wrapper**. The examples below explore the combination of specific device capabilities and social networks.

*Example 1.* We now have many single households, and if an individual would like to cook an Indian meal in company, this device may allow you to search through your social network for specific skills and characteristics, which you can combine in a "dinner team" with a set of complimentary skills such as cooking main meal, decorating the table, preparing desert and selecting/mixing drinks.

*Example 2.* We can use such a device to check the contents of our fridge before we start the cooking process, and even engage in a "virtual guide" mode of interaction to explore "what if" scenarios regarding different receipes.

You can have this C-Pod **implemented in OGS**I and deployed in such a way that services and features can be updated remotely without user participation.

#### *4.3.3. Is C-Pod a platform or a solution?*

In parallel to Blackberry, a C-Pod may be perceived as a solution. However, even if we start as to conceptualise the C-Pod as a solution, eventually the scope of collaboration support and the possibility of interoperating with a number of related devices and software components

will lead us to move to designing an upperware platform. This upperware platform will be developed within an iterative process; it can never be delivered in one shot. Once the platform is established, building a particular device would involve moving parts of this upperware platform to the device.

In the eyes of the customers, however, a C-Pod should look like a solution. You would sell particular C-Pod solutions to customers, whilst the C-Pod platform will be marketed to solution developers.

#### *4.3.4. Research challenges*

Explore the lessons from the commercial and social success of iPod, notably this was the first device which allowed users to buy their music through it.

It is therefore important to consider the **economic aspects** of the C-Pod, for example who will make the money from this and why the users will want to pay this money? Quality considerations will be important here.

Also relevant is the issue of **infrastructure economics**, for example the economic decision of fees one can charge against the investment required for creating websites-based infrastructure which provides collaboration services.

From the technical perspective, we need to research collaborative infrastructure which allows us to embed **p2p functionality** in the C-Pod, and combine this with server-based collaborative capabilities.

### **4.4. c-Etiquette**

#### *4.4.1. Definition and relevance*

Etiquette in collaborative context (C-Etiquette) considers implicit rules and behavioural nuances which enable face-to-face collaboration between people. This may be considered to be an area of social science and organisational behaviour on which software developers will draw to develop new Collaborative Working Environments.

When collaboration is **mediated by technology**, we have to deal with explicit models and representations of these rules and nuances to provide effective support for collaboration. C-Etiquette is thus important to structure groupwork and communication in the new virtual context.

#### *4.4.2. Research challenges*

The creation of a set of **social processes, models and methods** designed to complement any technical solutions is a difficult research challenge. However, any solution integrating such a set is likely to have a much better chance of being successful.

The definition of both normative and indicative c-Etiquette models should be based on analysis of best practices in different collaborative communities and contexts.

Once the set of norms and models is defined, an appropriate mix between individual and group tools should be defined to provide effective support for these norms.

Collaboration which uses ICT to bridge distances between collaborators poses its own challenges over and above those of coordinating face-to-face collaborative activities. This would include emotional characteristics which create feedback in a face-to-face meeting, yet when mediated through ICT they require effective modelling and representation design. The traffic lights metaphor, for example, can be used to indicate the time left till the end of a cyber-talk, when the speaker and the chair are not in a direct eye contact. Second generation such representations and their supporting tools allow audience to ask the person to speed up, or slow down.

Representations may be combined with processes, for example one may consider **the use of “serious games” as “icebreakers”** when forming a team out of people who have not met before.

Analysing characteristics of C-etiquette may uncover **differences between community and corporate C-etiquette**. The latter, for example, may cover a different set of norms and organisational behaviour. The two types of C-etiquette will be often intertwined, and in a corporate environment one may have to integrate and align the support for the two aspects of c-etiquette. This calls for the role of collaboration engineer.

## **4.5. Cooperativity**

### *4.5.1. Definition and scope*

Cooperativity may be formulated as the degree to which a CWE offers user-friendly and effective support for the collaborative process within a group.

Analysing the factors which contribute to cooperativity and creating appropriate **metrics** is important because of the expected take-up of new ways of collaborative working, which may lead to the end of the use of conventional documents.

Cooperativity is related to the inputs and outputs of the CWE, not to the way in which they are structured internally, although this internal structure may actually influence the cooperativity score.

### *4.5.2. Research challenges*

The main challenge would be to both promote cooperativity in regards to existing tool use, and **to embed cooperativity-supporting features** in future collaborative tools.

We need to devise a methodology to achieve and evaluate cooperativity. User Interface principles will be an important seed in the process, but we need to look at cooperativity as going beyond the user-computer boundary and as evaluating substance as well as form.

It is also important to determine which factors facilitate the uptake of cooperativity, and how is this related to the particular context. This analysis of factors would lead to techniques to support flexible adaptation to different contexts thus increasing cooperativity.

Differences between usability and cooperativity should be clarified further, and used to position cooperativity in respect to other “ilities” such as sociability, trust and privacy of the CWE.

Research should also cover **the way cooperativity is influenced by scale**, such as going from individual to organisation. Issues of both scaling up and scaling down should be investigated.

An interesting issue would be if cooperativity is related to the ability of CWE to support auditing of key coordination decisions and transparency in the way the CWE supports collaboration. This is very important in terms of health records, but it has now even started to be used on discussion newsgroups.

## 5. THREE BUILDING BLOCKS

**Rationale:** In order to achieve the stated vision of CWE in 2020, the RTD challenges identified in section 3 have to be addressed, and the Emerging paradigms have to be considered. From the practicality point of view, these RTD challenges can be translated into three 'operative' Building Blocks (BBs):

BB1: Collaborative infrastructures that fosters value creation, exploitation and preservation and stimulate creativity.

BB2: Reference models and patterns for CWEs.

BB3: New methods and concepts of work in various collaboration environments,

Fig.1. indicates how the eleven identified RTD challenges and Emerging Paradigms are mapped into these BBs. Please note that the figure indicates only the key BB where a specific challenge is addressed. In practice, each RTD challenge has to be addressed at all three BBs, e.g. the collaborative functions to be developed within BB1 have to address cooperativity and c-etiquette aspects as well, etc.

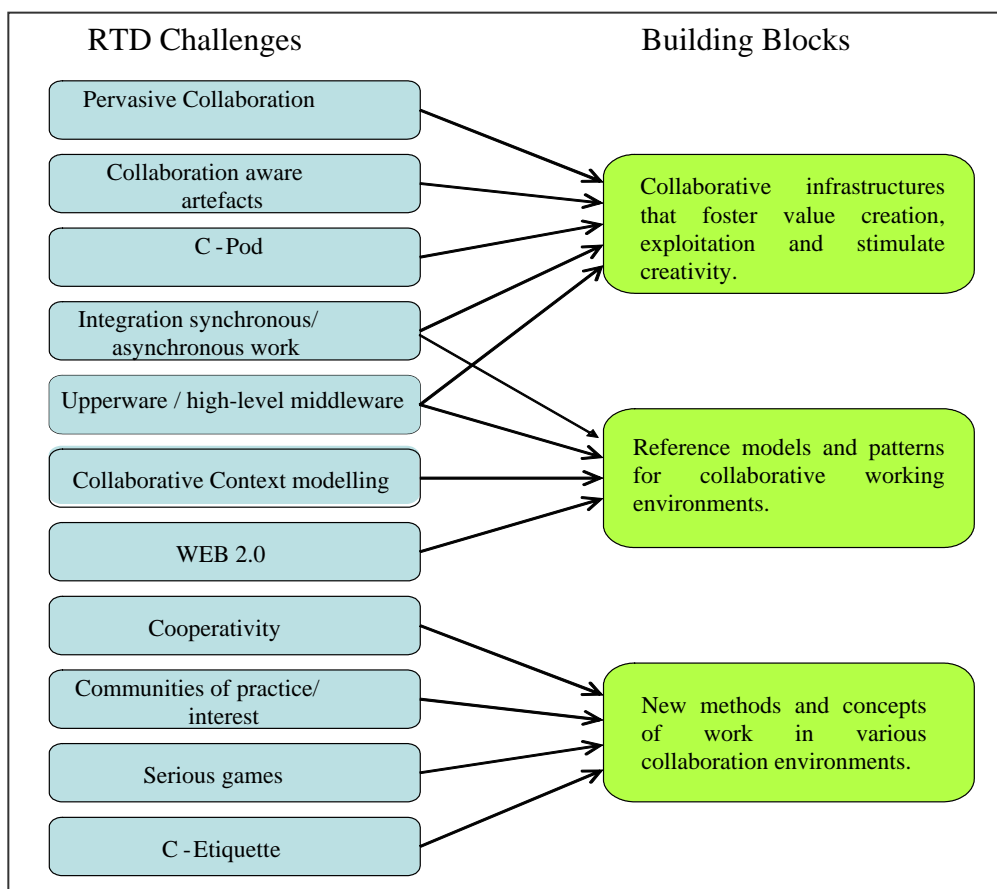


fig.1. Mapping of RTD challenges into Building Blocks

The rationale behind these BBs is to define three main groups of RTD activities: activities towards development of collaborative infrastructures (BB1), activities towards definition of reference models and patterns (BB2) and activities addressing methodological and conceptual aspects (BB3).

### **Definition of Building Blocks:**

#### **BB1: Collaboration infrastructures that fosters value creation, exploitation and preservation and stimulate creativity.**

This BB will focus on collaborative infrastructures, that is, software systems that provide functions to implement collaborative applications.

Collaboration infrastructures should provide pro-active support for dynamic patterns of collaborative interactions between humans, systems, machines and devices. The infrastructures will consider different platforms, e.g. c-pod, and will support features of collaborative applications. They will provide collaborative functions (system components) that will be wrapped up as collaboration services and exposed as service to the application developer, who might be the final user. Collaboration services will be automatically orchestrated and mashed-up into application-specific human-centric collaboration environments following a service orientation approach.

Collaborative infrastructures will provide three types of collaborative system components offering: generic, domain specific and context-specific functions. Generic functions provided by the infrastructure are generic and define basic components. They are provided as an abstraction to the next layer of domain-specific functions that build on top of generic collaborative functions and support the creation of application-specific collaboration environments. Finally, context-specific functions can build on both the previous blocks to create new functions related to pervasive collaboration, self-organization, integration of synchronous/asynchronous work etc. All these system components are wrapped-up and orchestrated following a service-oriented approach. Any block of the above infrastructure has to be supported by tools for collaboration design.

The functions provided by the collaborative infrastructures can be grouped into three blocks:

- **Basic collaboration functions:** peer group management, turn taking, content-based routing, context-aware interactions, shared access and visualisation of artefacts, distributed metadata query, finding patterns of interactions, multipoint videoconferencing, disconnected operations, personal and group information management, discussion features, decision making functions, goal management, group authoring, collaboration auditing, group and activity management, resource discovery, content and authoring provisioning, trust and reputation management, large-scale opinion management, team calendar management, etc.
- **Domain specific collaboration functions** include functions which are focused on providing added value for building CWEs in particular vertical (e.g., industrial) domains and include: Collaborative business protocol converters (e.g., discovery mechanisms for different protocols used inside one domain); Policy mechanisms enabling connecting multiple systems (e.g., Enterprise Resource Planning systems) into one coherent set of collaborative environments; Rule-based mechanisms for

specific domains (e.g., vertical industries) allowing for pre-configured repositories of plugable systems.

- **Context-specific collaboration functions** providing support for location dependent system components, time-awareness and culture responsive features, and organisation reactive functions needed by distributed collaborative networked environments,.
- **Collaboration design tools** for generation, composition, discovery, orchestration and scheduling of customised context aware collaboration tools/services. Collaboration infrastructures provide "primitives" which allow rapid composition, assembly, and orchestration of collaborative environments. Those collaboration infrastructure primitives contain conceptual blocks or functions (on a higher level of abstraction than methods) which allow reuse in many or most collaborative working environments, thereby reducing time-to-built for new CWEs.

**BB2: Reference models and patterns for collaborative working environments.** This will allow more consolidated and highly semantic interoperable and flexible cross-domain working environments. Built-in support will be provided for allowing collaborating entities to re-structure the team forms, and support evolving collaboration patterns and integration between synchronous and asynchronous work. Provide a framework to build activity oriented, context aware collaborative functions on appropriate level of abstraction based on generic communication and coordination primitives and mechanisms. These functions will be wrapped-up into services that will be composed into collaborative applications through automatic service composition and integration of basic functions, addressing as well security, privacy and IPR issues.

**BB3: New methods and concepts of work in various collaboration environments,** such as cooperativity, denoting the usability of a CWE for a group and a collaborative process, c-etiquette, considering implicit rules and behavioural nuances in collaborative work, application of experience from serious games for collaborative working environments, and communities of practice and of interest. These should be focused on the usage of the system through groups in a creative process so that organisations can leverage the full potential of CWEs to stimulate innovation, boost productivity and ensure that work goals are achieved. The challenge would be to both promote cooperativity in regards to existing tool use, and to embed cooperativity-supporting features in future collaborative tools.

### **Explanation:**

In definition of the BB the following aspects were considered:

#### **5.1. BB1: Collaborative infrastructure**

The BB1 focuses on providing collaborative functions that will be exposed as services to the user or the application developer. Theses functions can be structured in three blocks as indicated in fig. 2.

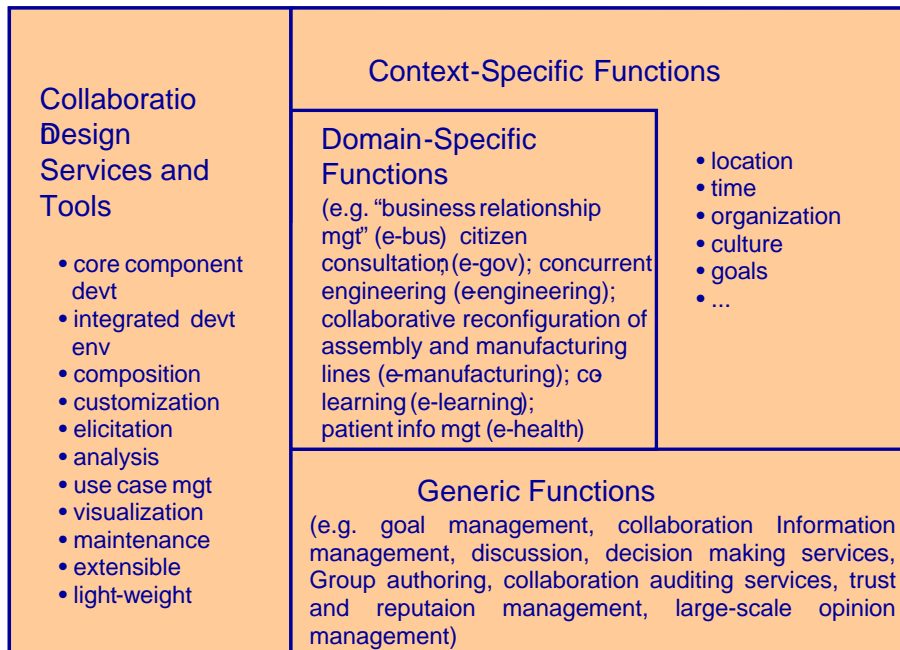


fig.2. Possible collaborative infrastructure

The first emphasis is that all these functions will be offer as services (generic services, domain-specific services and context-specific services) to the user or application developer. The **combination** of **generic** cross-domain services and tools with **domain-specific** ones will build application-specific collaboration environments, and a combination of generic and domain specific services with context-specific services will build situational specific collaborative applications. This reflects two key aspects of CWE – a key dual approach: generic cross-domain aspects and domain, application specific aspects.

The second emphasis is on services and tools for **collaboration design**, i.e. tools which either off-line or on-line support design of collaboration: development of core functions exposed as services and their composition, customization, update, maintenance etc. The objective it to contribute to blurring the boundary between designing and using, addressing implicitly or explicitly WEB 2.0 aspects. By this the ultimate goal of building collaboration services quicker, cheaper, more flexible, with higher quality will be achieved.

Different platforms have to be considered. **c-pod**, as explained in previous section, is one of possible options.

The **key RTD innovation** expected should include development of services for **pervasive collaboration**, self-organization, integration of synchronous/asynchronous work etc. The objective is develop **integrated activity-oriented, context-aware functionalities** supporting human interactions to enable **productivity and innovation** through empowered and motivated people to collaborate within their own organisations (distributed across time-zones and different spaces), with other organisations and with virtual communities of experts and of practice.

## 5.2. BB2: Reference models

Research on CWE should focus on reference models for semantic collaborative working, and on seamlessly integrated activity-oriented, context-aware collaboration functions. The key emphasis is therefore on **context modelling and awareness and activity oriented functions**.

The objective is to support **semantic interoperability**<sup>1</sup> and assure flexible cross-domain working environments in which functions (developed under BB1) could be effectively re-used. The objective is to stress system thinking in defining **‘upperware’**.

The next emphasis is on **evolving** (dynamically changing) **collaborative patterns**, aiming again to **support integration of synchronous and asynchronous work**.

The reference models should support **‘automatic’ composition and integration** of basic functions exposed as services, taking into account WEB 2.0 paradigm.

The idea is to provide (set of) de-facto reference **models** applicable in different domains, and not fixed models but reference models which will **evolve** in time. Therefore, the **process of defining** the reference models is key issue. The objective is to identify an **appropriate level** of abstraction of such models: not too rough to prevent interoperability and re-usability, but not too detailed to restrict development and creativity.

Explicit RTD challenges arises from the need to empower people to work both **in unstructured teams and in well-defined and stable settings** through evolving CWE reference models for seamlessly integrated activity-oriented, context-aware collaboration functions that provide enhanced knowledge sharing mechanisms, better decision making process and less burdensome group processes support. The **security and IPR issues** have to be considered.

The **RTD challenges** to be addressed are, therefore, context modelling, activity-oriented CWE, evolving collaboration patterns and integration of synchronous and asynchronous work, WEB 2.0 issues.

### **5.3. BB3: New methods and concepts**

The third BB is dedicated to methodological and conceptual aspects on collaborative work.

The emphasis is on cooperativity, **serious games**, c-etiquette and communities of practice and of interest.

The key challenge concerning **cooperativity** is to define methods to examine cooperativity in regards to existing tool use, and to develop new approaches to embed cooperativity-supporting features in future collaborative tools.

Concerning the **serious games** it has to be investigated how gaming models and methodologies could be re-used to increase motivation and enhance outcomes. A study on motivation and learning by exploration strategies in games and generating models and conclusions which are transferable to the serious games domain is needed, including assessment of both easily transferable elements such as UI and elements which would require further work before they can be transferred.

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<sup>1</sup> **Semantic interoperability** could be defined as the ability to integrate resources (elements) that were developed using different vocabularies and different perspectives on the data.

The above addressed aspects related to **c- etiquette** have to be studied. The issues of **identity** rather than privacy and corporativity have to be examined.

The challenge is to examine collaboration among organised groups (e.g. in industry, business etc.) and different communities within and across organisational social boundaries. Specific methods and tools are needed for the creation, persistence and effective action within communities and their collaboration with the organised groups.