Multiparty Session and Network Resource Control in the Context Casting (C-CAST) project

Augusto Neto[1] , Susana Sargento[1,2], Evariste Logota[1,2], Josephine Antoniou[3], Filipe Pinto[4]
[1] Institute of Telecommunications, Aveiro, Portugal
[2] University of Aveiro, Portugal
[3] University of Cyprus, Cyprus
[4] Portugal Telecom Inovação. Aveiro, Portugal
augusto@av.it.pt, susana@ua.pt, logota@av.it.pt, josephin@ucy.ac.cy, filipe-c-pinto@ptinovacao.pt

Abstract. The explosive increasing demand of citizens and businesses in multimedia group services, personalization, context-awareness and seamless mobility, imposes stringent and heterogeneous requirements, which cannot be satisfactorily addressed through the traditional transport control architectures for session content delivery. In future scenarios, context-aware services and multicasting will together drive a new trend, since context-awareness can exploit situations in which users share the same interests and request similar services, increasing the effectiveness of session and network control. In these environments, where groups may be created based on context, multicast takes a new lead to the communications environment. However, context-aware networks also introduce personalized concepts: any change to context, such as, location, mobility, velocity, preferences, presence, can change the overall services and network environments, requiring the network and multicast sessions to be completely restructured in a very dynamic way. This dynamicity poses scalability problems in current networks. In this paper, we propose an efficient architecture for context-aware multiparty session and network control which dynamically adapts to contexts' and networks' dynamics and maintains the connectivity with the expected requirements over session lifetime. We consider the concepts of dynamic session and network control, driven by context, but introduce the concept of abstract trees in the network to increase the stability of the network to any context change. The practical scenarios studied in the paper demonstrate that such a context-aware design paradigm tends to be a very essential approach for the future Internet where unpredictable variables such as user, environment, networks and session contexts make the diverse users Quality of Experience (QoE) harder to satisfy.

Keywords: Multimedia, Context Awareness, Multiparty Sessions

1 Introduction

Currently, service providers are focused in defining new types of service so as to attract customers that are more and more demanding. With the increasing demand of multimedia content by several users simultaneously, efficient solutions are under investigation aiming at allowing the efficient propagation of multiparty sessions, such as IPTV and push media. Moreover, the limitations of existing environments (e.g., Internet and 3G networks) to efficiently fulfil the strong resource requirements of such multimedia sessions motivated the research community to propose alternatives. Thus, the next generation of networks is envisioned to support a wide range of multimedia sessions ubiquitously and independently of the underlying network technologies. On another perspective, context-awareness has recently attracted attention by the research community, since a wide number of information can be available describing specific characteristics of objects and environments, such as devices, applications, places. This information will have strong influence on the services to be provided and their characteristics. Context-aware applications and networks should react to context changes to take more efficient decisions according to the environment, session, users/terminals and network characteristics. For instance, mobile terminals can automatically switch from ringing to vibrating mode inside noisy environments (concerts, games) or places requiring silence (theatres, classes, museums); location-based services allow sending advertisements to terminals attached to cells in range of catastrophes situations (e.g., accidents, hurricanes, earthquakes); in a more traditional networking side, efficient re-routing can be deployed when changes in context of networks and users are detected, such as link failures and terminal handovers, respectively.

The Context Casting (C-CAST) project [1] aims to design a new approach to allow personalized session content delivery to multiple mobile users, independently of the underlying network access and transport technologies, and taking context sources and information into account to optimize the content delivery. In C-CAST context-awareness is considered to allow the collection and delivery of information about mobile terminals, network and environment, so that dynamic events can trigger session and network reactions, such as service and network re-configuration, multiparty session content delivery and re-negotiation, and seamless context-aware mobility. Resuming, the aim is to have a cognitive network driven by context, to efficiently react to context information and changes. With this aim, C-CAST project aims to specify an approach composed by well-defined components capable to dynamically support multiparty content session delivery to mobile terminals in context-aware environments. These components are being defined by three main sub-systems: session enablers and context management, context detection and context-aware multiparty transport, and content creation, discovery, storage, processing and delivery.

This paper aims to propose components, interfaces and functionalities for the context-aware multiparty transport sub-system, which aims to fulfil such requirements by including capabilities to: *(i)* collect and make available context information; *(ii)* dynamically match and establish multiparty content sessions; *(iii)* allocate network resources in a scalable manner with support to self-organizing operations for resilience; *(iv)* control terminal mobility seamlessly.

This paper is organized as in the following. Section 2 describes the C-CAST approach. Section 3 describes in details the context-aware multiparty transport sub-system, its components, functionalities and interactions. Section 4 provides the conclusion and points for future work.

2 Context Casting Approach

C-CAST is targeting two main technology areas: provision of context awareness and QoS-aware multicasting. The project will research, investigate and define new ways to use user's and network's situation/environment as basis for creating context information that can be used for the provision of multicast group sessions. This environment-mediated multicast may be triggered by an event in the physical environment offering a situation or context oriented service. C-CAST will provide an end-to-end context creation, reasoning and distribution framework to addresses three functional issues: *(i)* development of context and group management session enablers for context representation, context assisted group management and context reasoning; *(ii)* definition of a framework to collect sensor data, distribute context information and manage efficiently context aware multiparty and multicast transport; *(iii)* and development of mechanisms for autonomous context driven content creation, adaptation and media delivery. Fig. 1 shows the frameworks and interfaces between them composing C-CAST functional architecture.

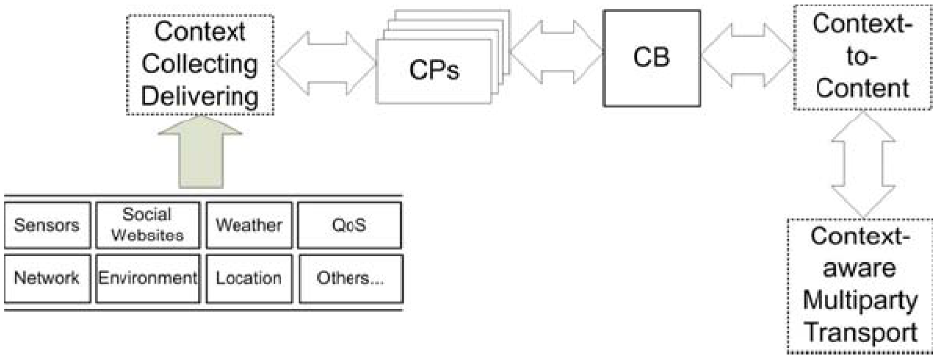

Fig. 1 Functional architecture of C-CAST project

The components of the *Context Detection and Distribution* framework are responsible to collect/detect context and keep the information in elements called Context Providers (CPs). The environmental context at user side can be acquired from sensors (e.g. location, speed, etc) attached to the user terminal and complemented with the network's view of the environmental context acquired from e.g. wireless sensor networks deployed in the user's vicinity (e.g. location, temperature, etc). Once reasoned, such environmental context can lead to the detection of complex events, like for instance a user moving into or out of a building (e.g. using location and temperature information) and the adaptation to this new context (for instance by turning on/off Wi-Fi scanning on the terminal). Similarly, the user networking context encompasses both information that can be perceived/obtained at the terminal side (e.g. available links, links quality and characteristics, etc.) as well as information only available in the network (e.g. cells load, etc). All those contexts are delivered to a context management system, which then selects the correct CP for storage. The information stored in CPs can be retrieved via an element called Context Broker (CB), which is being defined by the C-CAST session enablers and context management sub-system, CB can also be configured to dynamically provide context, such as when reached a pre-configured threshold or detected events/conditions (e.g. subscription of a new user with a certain profile). The Context-to-Content framework is being designed by the content creation, discovery, storage, processing and delivery sub-system, aiming at reacting according to the context provided by CB, to select content sessions and potential destination users. The Context-aware Multiparty Transport framework allows the content delivery along network infrastructures. Cross-layer interactions between C-CAST frameworks and sub-systems will be allowed by well-defined interfaces, which are out of scope of this paper. In this paper we aim to propose components, functionalities and interfaces for Context-aware Multiparty Transport framework. The next section describes the proposed solution.

3 Context-Aware Multiparty Transport Framework

The key objective of Context-aware Multiparty Transport framework is to provide ways to use context to efficiently support dynamic group-based content delivery, taking into account context information to optimize the delivery process, both in terms of the network, users and service requirements, in a scenario of mobile and multihomed users. In order to simultaneously deliver data to multiple receivers, IP multicast will be adopted since its bandwidth-constrained scheme allows packet duplication only as needed. However, besides optimizing bandwidth consumption, IP multicast cannot provide bandwidth assurance to QoS-constrained sessions, such as video/audio conferences and IPTV. Hence, it is required to associate IP multicast with QoS control schemes, at least to deploy ways for access control and bandwidth assurance to

prevent denial of service/quality. Nevertheless, such integration is not trivial due to scalability problems and divergence in architectural design [2]. In the envisioned environment, dynamic and mobile, with changes of context influencing the sessions and network, with constant re-configurations, it is required to support a session and network multiparty control framework that is able to react, in a scalable way, to these context changes without damaging the quality of experience seen by the users and optimizing network resources.
Existing technologies are both not (yet) globally available and still insufficient, making it very difficult in practice to provide seamless and pervasive group communications. Indeed, it is almost impossible to deliver content to all group members in the same way due to their individual heterogeneous aspects, such as in terms of link capacity, network conditions, device capabilities, mobility and environmental circumstances. Such requirements enforce the need to support dynamic resource adaptations, so that network performance can be optimized, as well as the satisfaction of each user. C-CAST enabled environments are expected to drive efficient and intelligent multiparty delivery adaptations, since available context may describe and influence networking of each group member (i.e. link quality and capabilities), user (device capabilities, available technologies, subscribed networks, etc.) and environmental context (noising, velocity, physical location, speed, etc). In order to fulfil such requirements, current Internet requires optimizations practically at all levels of its protocol stack.

3.1 Components

Based on the inability of current Internet architecture to fulfil C-CAST requirements, the context-aware multiparty transport framework aims at specifying components, interfaces and functionalities for the envisioned described requirements, with optimizations at session, transport and network layers. Fig. 2 shows the Context-aware Multiparty Transport proposed components and interfaces in the scope of Internet stack.

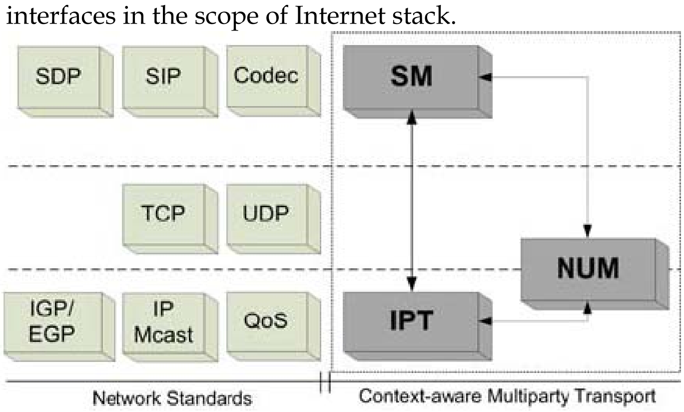

Fig. 2 Multiparty Transport Modular Architecture

The Session Management (SM) acts in the session layer to control and maintain sessions and groups of users by means of QoS adaptation, transcoding, session adaptation and (re-)negotiation, and sub-grouping. The Network Use Management (NUM) operates in the transport layer to provide the best transport of multiparty data delivery in heterogeneous environments, in terms of unicast and multicast. In the network layer, NUM deals with network selection to keep each multihomed user receiving multiparty content in the most appropriated network interface, and throughout the best network. The Internet Protocol Transport (IPT) is at network layer to deploy scalable setup of network resources for QoS-aware multiparty delivering, with supporting resilience and seamless mobility.

3.1.1 Session Management

SM controls all user-to-content and content-to-user relationships. Specifically, it works as an overlay between applications and networks, being agnostic to the access technologies. SM handles session control events, more specifically: session establishment, session re-negotiation (upon a given trigger or change) and session termination. Furthermore, group members can be split into sub-groups corresponding to different media encodings of the same content with the objective to provide to each user the coding scheme that best meets his/her context (e.g. codecs available on the terminal, link quality, etc.) and current network conditions, and provides the signalling to deliver a specific content to its consumers. Additionally, SM composes the session context, which describes the session characteristics (by means of the selected codec) and QoS requirements (tolerance to delay, loss rates and jitter), as well as the ID of members of the group. SM functional entity plays the role of intermediary between end-users and their matching content. It triggers the link between the entity responsible for transmitting content to users, and the content receivers. The SM enables the content to be transmitted at the appropriate QoS for the given session by using specific signalling and interaction with NUM and IPT, for connecting the content source and the multiple receptors, which can be hosted at any IP based network.

There are several situations in which the SM plays a mandatory role. Whenever a user intends to join or leave a multiparty group, SM is required to trigger the appropriate network resource control. This requirement may be differentiated according to the type of network, the terminal capabilities and the context information. Furthermore, due to the networks' dynamics as well as user situation modifications which can lead to a new type of media, such as a new audio or video stream, SM must be capable of re-negotiating the content leading to a modified or even new session. SM participates in dynamic changes, such as switching between different content, achieving a dynamic SM nature for the C-CAST context-aware, heterogeneous system.

3.1.2 Network Use Management

NUM aims at using context about user, environment, network, and session to drive intelligent network selection and multiparty transport delivery control seamlessly and ubiquitously. User, environment and network context can be retrieved in the Context Providers (CPs) by means of the Context Broker (CB). Session context can be retrieved by the SM. Network selection is an important functionality of NUM since it is assumed that networks will contain simultaneously available different access technologies (e.g., Wi-Fi, WiMax, UMTS, GPRS, etc) with overlapping coverage areas. Literature review shows the lack of current standard solutions to deal with multihomed scenarios. The *Stream Control Transmission Protocol* (SCTP) [3] has no support to simultaneous communication on different interfaces, reordering and load balancing, as well as it is not able to provide information on how to select the best path. The *Host Identity Protocol* (HIP) [4] evolves towards mobility management without support to provide information about technologies and QoS attributes of local network interface, which is crucial to take efficient decisions. Objective [5] and Profit [6] function mechanisms are not transparent to the users, since they ask data user for decisions. Consumer surplus [7] on the other hand uses a user-centric approach which may not be good for load balancing of the whole network. Stochastic programming approach [8] is designed for supporting a single common service with fixed required bandwidth, which is not appropriate to a variety of services along with various bandwidth requirements.

The context-aware intelligent network selection of NUM is being designed to overcome the limitations of the aforementioned solutions, by considering users, environment, session and network contexts to keep multimode terminals always "best" connected. Moreover, it is expected to achieve more efficient utilization of the available wireless resources, as well as more uniformly distribution of data load while fulfilling the QoS required by sessions and experienced in the users. However, allowing dynamic accommodation of terminals in heterogeneous scenarios, taking into account and reacting to any changes of context, increases the network dynamics and complexity. Therefore, a new concept of network architecture needs to be envisioned to control the system complexity. For this purpose, NUM defines a new concept operating on top of the IP network layer, aiming at allowing general transport control in multiparty trees to hide the dynamicity of the network, as well as changes in the multiparty session and tree. Related work

analysis raised the lack of generic multiparty support at the transport layer (some multiparty technologies are application-dependent while others do not support IP multicast).
The main idea behind the abstracted transport resides in defining overlay transport structures called Abstracted Multiparty Tree (AMT). The AMT principle consists in allowing end-to-end multiparty content transport over network segments with different transport technologies (i.e. unicast and multicast), local self-organization and seamless resilience support. Local network segments are called sub-AMTs, where all nodes (edge and core) composing a sub-AMT implement the same transport technology. NUM must coordinate the edges of each sub-AMT, called Overlay Nodes (ONs), to implement proxy functionalities for mediating overlay connections. In the scope of a sub-AMT: *(i)* ingress ON is viewed as a session source; *(ii)* egress ONs as leaf nodes (or receivers); *(iii)* and core nodes remain simple by mainly deploying IP forwarding operations. Fig. 3 shows a network scenario with different AMTs to supply multiparty transport for sessions S1 and S2.

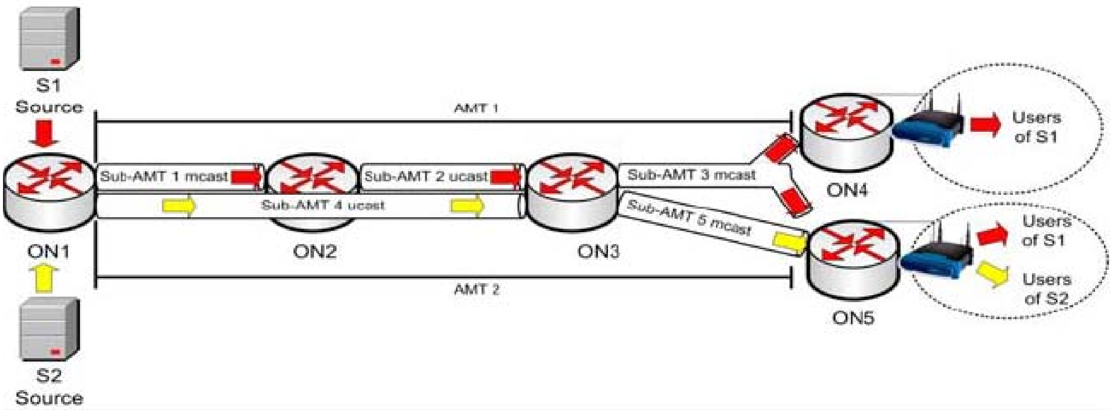

Fig. 3 Edge-to-Edge Abstract Multiparty Trees and interior Sub-abstract Multiparty Trees

NUM will control AMTs taking into account scalability and reliability, allowing management of transport connections by creation, deletion, pull and push operations at the transport layer. To properly "route" multiparty packets from the source to the receivers over the Sub-AMTs, each ON maintains mapping information between the multiparty transport connection ID and the IDs of associated multicast and unicast connections. Thus, Sub-AMTs can be controlled independently from other Sub-AMTs, and also implement different address helms, QoS models, and transport technologies. For instance, a group member can move from an IPv6-only multicast-capable link (e.g. Wi-Fi) to an IPv4-only unicast-only capable link (e.g. GPRS) while preserving the continuity of the session (in a manner transparent to the user and application). Under congestion detection, SM can perform QoS adaptation to adjust the QoS requirements of the session to the current network conditions.
The main idea when deploying the AMT concept is to increase scalability of the approach in very dynamic scenarios: if required changes can be performed in the core part of the network inside the same AMT, it is not required to change the AMT overlays, neither it is required to access NUM to perform context-aware network decisions. Only when it is required to change the overlay nodes, both NUM and AMTs will be triggered.

3.1.3 IP Transport

IPT aims to coordinate the allocation of network resources to allow the propagation of multi-party content sessions to groups of users, with QoS-guaranteed over the time,. The main requirements of IPT include the support of: *(a)* integration of QoS and IP multicast control; *(b)* scalable signalling approach; *(c)* fast resilience operations; *(d)* setup of network resources; *(e)* QoS mapping.

IPT handles network resources aggregately (per-class) to overcome the performance shortcomings of existing per-flow approaches. For instance, the wide used Resource Reservation Protocol (RSVP) [9][10], a standard solution that places excessive signalling/state, thus processing overhead, to configure and maintain resources for each micro flow. Additionally, IPT aims to avoid too much centralized control, such as in TISPAN [11], for scalability and fault tolerance. In the scope of multiparty transport, IP multicast is not efficient due to the high signalling and state overhead placed by the per-flow basis of legacy multicast protocols (e.g., Protocol Independent Multicast (PIM) [12] and Source Specific Multicast (SSM) [13], as well as the lack of QoS support and access control, which is essential.

The performance limitations of existing proposals motivated to design IPT with support to distributed per-class resource control, thus whereas session establishment can be requested in a per-flow basis, resources are configured per-aggregations. For scalability, network edges coordinate resource allocations and interior routers remain simple by reacting only upon both signalling and network events (e.g., link failures, re-routing or mobility), where these events can be local or triggered by context changes (through NUM). As input, IPT takes session context and collects network context direct from devices or QoS-CPs (CPs with QoS information about nodes, paths and etc.) via a well-defined API. IPT must be prepared to interact with elements (packet scheduling mechanisms, QoS approaches for mapping, unicast/multicast routing protocols, etc.) of different network technologies to deploy resource allocations and build delivery trees in heterogeneous environments.

Among the functionalities supported by IPT, we can list admission control, per-class resource reservation in different QoS models, control of IP multicast trees and detection of re-routing conditions. IPT aims to support resilience operations seamlessly. In another words, IPT attempts to reconfigure multicast trees without changing the current IP multicast address and preventing additional user re-subscriptions. For local re-configurations, IPT will re-configure the tree with the appropriate requirements, and no changes are required in the other framework components (SM and NUM). The benefits of such process include energy consumption in users, reduction of session disruption during handovers due to processing and signalling overhead, user satisfaction, etc. The other components are only triggered by IPT if really necessary. For instance, when IP multicast address are changed, IPT must trigger NUM to reconfigure transport connections with new destination address, as well as SM to signal user to re-subscribe the new tree.

3.2 Context-aware Multiparty Transport Architecture

In this section we depict the proposed architecture and how the different elements interact to support the context-aware multiparty service delivery. Whereas both SM and NUM components are implemented on a central station called C-CAST Broker, IPT is placed on all nodes within the environment. As an extension to this architecture, we also plan to develop NUM functionalities distributed in the network, with local cooperative decisions between the network nodes. The ONs implement an overlay agent for proxy functions, and can be implemented in strategic nodes, or everywhere (depending on the network operator decisions). The SM and NUM must be supplied with information about: *(i)* the CB; *(ii)* all available ONs; *(iii)* and the networks attached to the egress ONs. Beyond controlling multiparty communications to keep mobile users always "best-connected", context-based adaptation of the multiparty delivery aims to enable pervasive access to the group communication as well as its seamless continuity despite mobility of group members, re-grouping, or context changes that require change in session or network conditions. Fig. 4 shows how components can be placed at edge and core routers within, and interactions, a general C-CAST enabled environment.

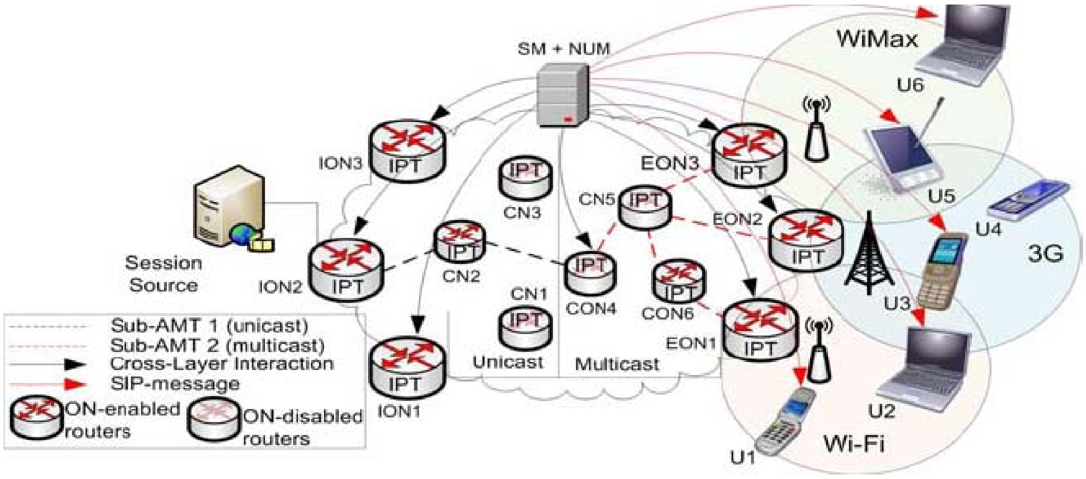

Fig. 4 General C-CAST enabled environment

Whenever a session is to be established, SM firstly negotiates with NUM the quality that can be supported by each user to create a group of a set of sub-groups. In this sense, SM triggers NUM in a per-user basis indicating a list of codec possibilities. NUM retrieves context of each user via the CB, and triggers SM back with a hank score for each codec possibility. Based on such information, SM performs grouping/sub-grouping and composes each session context accordingly (for the group or for each sub-group according to the selected codec's). Afterwards, SM invokes NUM for the session establishment. The Session Setup functionality defines a set of operations that must be deployed to establish a session within a network. In addition, the session setup is also used in resilience operations, where new paths require the setup of a new session. Obviously, such operations must be skipped when the indicated session is already activated, preventing thus redundant configuration. The session setup operations are illustrated in Fig. 5, and take into account the general environment of Fig. 4.

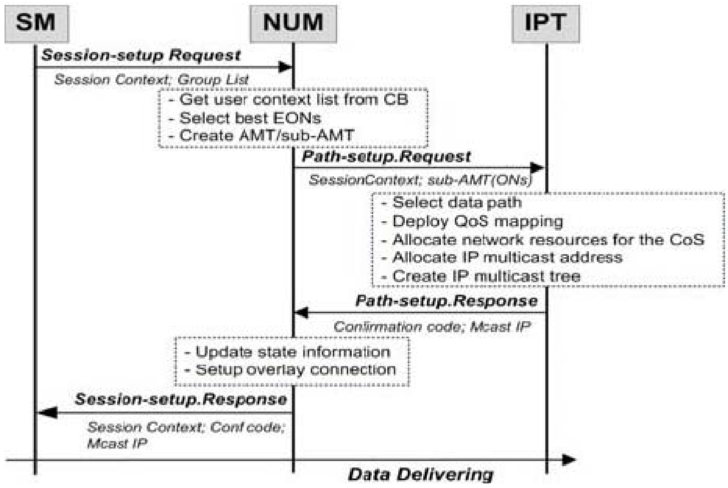

Fig. 5 Normal Session-setup operations in the Context-aware Multiparty Transport

Upon receiving the *Session-setup.Request* triggering from SM, carrying session context and information about the related group, NUM triggers the CB with a list of user IDs (e.g., IP address) to get context about each indicated user. After received the list of user contexts from CB, NUM computes the ONs that can be used. Subsequently, NUM retrieves network context of each ON and about the wireless networks associated to each user. According Fig. 4, the ONs implemented in the environment are ION2, EON1, EON2 and EON3 as edges, and CON4 and CON6 (multicast-enabled) as core nodes with overlay capabilities. Firstly, NUM selects the most appropriated edge ONs as support for network selection of each group user. After selected the best network for each user, NUM creates an AMT for the session. Then, NUM select the best way to deploy multiparty connectivity inside the AMT, that is, create sub-AMTs based on network context. NUM realizes that the AMT do not supports end-to-end multicast, since CN2 do not implements IP multicast. Hence two chooses to create two sub-AMTs, the unicast–enabled sub-AMT and the multicast-enabled sub-AMT2, where CON4 is the connection point between sub-AMT1 and sub-AMT2. Next, NUM triggers IPT in the ingress ON of unicast-enabled Sub-AMT 1 (ION2) to setup network resources up to the corresponding egress ON (CON4). Firstly, IPT performs admission in ION2, and after succeeding, the bandwidth reservations and QoS mapping are deployed. After that, NUM signals the communication path towards CON4, where CN2 is visited by the message and deploys the same operations as ION1. After finished the operations, CN2 forward the message, where CON4 deploys the same set of operations and sends a response message to ION1 confirming the success. At this time, INO1 configures proxy functions with the original unicast address and communication ports. After succeeding the Sub-AMT1 setup NUM sends a Session-setup.Request to IPT in CON4 to setup the multicast-enabled Sub-AMT 2. After succeeding admission control operations in the network interface from CON4 to CN5, IPT deploys the QoS mapping and resource reservation and allocates an IP multicast address (via a standard dynamic multicast address allocations solution, such as MADCAP). Next, IPT signals CN5 with the Session-setup.Request so that it can do the same taking into account EON 1, 2 and 3 as destination nodes. In CN5, IPT updates the local Multicast Routing Information Base with IP of the previous router (i.e., CON4), to force multicast routing protocol signallings to correctly create the QoS-aware multicast tree. IPT in CN5 sends a Session-setup.Request signalling to each EON, where after succeeding the session setup operations, a Session-setup.Response message is sent to CON4 confirming the successful process. Moreover, each EON triggers the available multicast routing protocol to create the IP multicast in reverse path crossed by the Session-setup.Request signalling (since the MRIB is correctly supplied with the QoS-capable information). Not that, besides CON6 implementing overlay functions, it will act as a normal router since overlay is not used in this node at this time.

At CON4, IPT triggers NUM in the C-CAST Broker, which then triggers SM (at the same node) to send a SIP message to each user to subscribe the Sub-AMT 2. If the admission control of IPT detects that the available bandwidth is not enough to establish the session, NUM is triggered to request SM for QoS adaptation. The session must be denied whether the QoS adaptation cannot be succeeded. In what concerns resilience, IPT is prepared to detect re-routing. Such detection can be possible by intercepting routing advertisements or network management alarms. In the mobility scope, it is required a mobility controller to detect handover and access points candidates (strongly considered for further investigations).

Considering a link failure in Sub-AMT 2 (Fig. 4), IPT is able to re-build the IP multicast tree only inside it. If neither the egress ONs nor the IP multicast address changes, IPT restores the IP multicast tree without interacting with NUM. Any change in the hereinabove information require interaction with NUM and SM to select a new egress ON and signal affected users to subscribe the new IP multicast address. However, the architecture is built hierarchically, with the support for the abstract trees, to prevent the change of the network due to the change in context. Whenever it is possible to perform all required changes just resorting to IPT, the abstract trees are not changed and both SM and NUM remain free to support other tasks. This is very crucial for the scalability of the approach. There are also some context changes that trigger directly the NUM and SM. As a NUM triggering example, the detection that many users are approaching an area and listening to high bandwidth content requires NUM to determine the best networks for these users and the ones already in place, and this will trigger the network re-configuration (AMTs and IPT) and possibly the mobility of some users for different networks. Moreover, this movement may require the sessions to re-negotiate their parameters, and the SM is contacted for this purpose. As an SM triggering example, in a scenario with large noise, SM may be contacted by the Context Broker to change the session and remove the audio. This will also have impact on the network part, and IPT is contacted to update the network reservations. If this context change requires new optimizations in the network, NUM will determine the best connections for the multiparty sessions, and the decisions are mapped in IPT. Again, NUM may construct a new sub-AMT only if the new network configurations change the abstract transport tree.

4 Conclusions and Future Work

This paper proposed a new session and network control framework for the support of the delivery of multiparty content in context-aware dynamic environments. This framework needs to support, in a scalable way, the optimized multiparty session delivery in these dynamic environments. For this purpose, we presented an architecture with components, interfaces and functionalities for the context-aware multiparty transport sub-system, which aims to fulfil the envisioned requirements by including capabilities to: *(i)* collect and make available context information; *(ii)* dynamically match and establish multiparty content sessions; *(iii)* allocate network resources in a scalable manner with support to self-organizing operations for resilience; *(iv)* control terminal mobility seamlessly. We also depicted the interactions between the different elements in specific scenarios, of session setup, re-routing, network and session optimization, including mobility situations.

As future work we plan to develop an internal algorithm of NUM and SM for the optimization of session and network control, namely the algorithms for intelligent network selection and construction of abstract multiparty trees in dynamic context-aware environments, and assess its efficiency and scalability when compared to the mechanisms support in current networks. The support of distributed approaches for network decisions will also be explored.

References

[1] Context Casting (C-CAST) project, EU's ICT 7th Framework Programme, http://www.ict-ccast.eu.

[2] Neto, A, Cerqueira, E., Rissato, A., Monteiro, E., Mendes, P.: A Resource Reservation Protocol Supporting QoS-aware Multicast Trees for Next Generation Networks. In: 12th IEEE Symposium on Computers and Communications, Aveiro (2008).

[3] Stewart, R.: Stream Control Transmission Protocol. IETF, RFC 4960 (2007).

[4] Moskowitz, R., Nikander, P.: Host Identity Protocol (HIP) Architecture. IETF, RFC 4423 (2006).

[5] Koundourakis, G., Axiotis, D.I., and Theologou, M.: Network-based access selection in composite radio environments. In: IEEE Wireless Communications and Networking Conference 2007, Hong Kong (2007).

[6] Liu, X., Li, V. O. K., and Zhang, P.: NXG04-4: Joint radio resource management through vertical handoffs in 4G networks. In: IEEE Global Telecommunications Conference 2006, San Francisco (2006).

[7] Ormond, O., Perry, P., and Murphy, J.: Network selection decision in wireless heterogeneous networks. In: IEEE 16th International Symposium on Personal, Indoor and Mobile Radio Communications, Berlin (2005).

[8] Taha, A.-E.M., Hassanein, H.S. and Mouftah, H.T.: On robust allocation policies in wireless heterogeneous networks. In: First International Conference on Quality of Service in Heterogeneous Wired/Wireless Networks, Dallas (2004).

[9] Braden, R., Estrin, D., Berson, S., Herzog S., and Zappala, D.: The Design of the RSVP Protocol. ISI Final Technical Report (1996).

[10] Braden, R., Zhang, L., Berson, S., Herzog, S., and Jamin, S.: Resource Reservation Protocol (RSVP) -- Version 1 Functional Specification. IETF RFC 2205 (1997).

[11] Kurokawa, A., Higashi, I.: Standardization Trends of the Next Generation Network in ETSI TISPAN. Journal NTT Technical Review, Vol. 4, No. 6, pp. 53–57 (2006).

[12] Estrin, D., Farinacci, D., Helmy, A., Thaler, D., Deering, S., Handley, M., Jacobson, V., Liu, C., Sharma, P., Wei, L.: Protocol Independent Multicast-Sparse Mode (PIM-SM): Protocol Specification. IETF RFC 2362 (1998).

[13] Holbrook, H., Cain, B.: Source-Specific Multicast for IP. IETF RFC 4607 (2006).