Context Aware Multiparty Session Support for Adaptive Multicasting in Heterogeneous Mobile Networks

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Abstract. The paper addresses the issue of achieving context-aware, adaptive multiparty sessions in a heterogeneous system by illustrating how to add elements of adaptivity and context-awareness to the session management functionality of such systems. The effective usage of situation/context information can lead to context-aware content casting, especially context-aware, adaptive multicasting. Therefore, regarding the multicast service, the key functionality of the enhanced session management is to create network subgroups based on network information as well as general user and environment context information to the extent that these are considered necessary for forming network-efficient groups, and in turn communicating the characteristics of these subgroups in the form of content stream descriptions to the media delivery function for obtaining the appropriate content for each subgroup.

Keywords: session management, context, multicasting, heterogeneous mobile network, adaptivity.

1 Introduction[1]

Recent years, from about the early 2000s have been characterized by global broadband penetration, Fixed-Mobile-Convergence, Triple Play and content provisioning over All-IP networks, whether text, audio or video data. The Telco world is currently challenged by the competition with the Internet and their quick time-to-market service provisioning. YouTube, Apple iTunes and social networking platforms like Facebook have impressively proven the dynamics of this new market led by the typical wired Internet services. Indeed, the Internet domain challenges the Telco's

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business models massively, now aiming to catch the Web 2.0 opportunities. However, the goal is not to fight the Internet but to use similar but Telco-enhanced assets in a greater extent, adding elements of adaptivity and context-awareness, e.g. the user's context information can lead to context-aware content casting, and for group-oriented services, context-aware, adaptive multicasting.

Context, understood as sensed information that changes over time, has already led to some extent to service adaptivity in terms of recognizing and using simple context, e.g. location. Context may also include network state, location, weather or personal state. To allow for session adaptivity in specific services, such as multicasting addressed in this paper, it is key to use network context as well as user context to enhance the existing service adaptivity. Such enhancement would enable more efficient management of network resources while keeping the user satisfied throughout the multicast session. Context-aware multicasting is based on the creation of context awareness and the technology of mobile multicasting. There is a lot of ongoing research in context detection and sensing. Moreover, mobile multicasting technologies such as MBMS or eMBMS (evolved MBMS, based on LTE, with much higher bandwidth than MBMS) are already focused. What is interesting is the coupling of both, context detection and sensing, together with their management as a unified system.

Session Manager is the entity in a Core Network architecture that manages all the user-to-content and, vice versa, the content-to-user relationships [7]. In fact, session management provides the necessary signaling to deliver a specific content to its consumers, handling different types of events regarding session control, specifically: session establishment, session renegotiation (upon a given trigger or change), session termination and session mobility. Session management thus participates in dynamic changes as for example switching between different content.

Since session management is closely interlinked with media delivery, it is the responsible entity to ensure that the appropriate content is delivered to a given user and it acts as an intermediary platform, a middleware, between the content provider and the content consumer. It is thus the appropriate middleware to consider the coupling of the user context-awareness and the multicasting technology. This paper extends the session management functionality for multiparty sessions to consider context triggers in the creation, modification and teardown of sessions. With the proposed enhanced Session Manager, multiparty content distribution will be done in the most efficient way.

The rest of the paper is as follows. Section 2 presents the motivation for this work including a description of how context is viewed in networking, a usage scenario, session management related work and open issues identified from a generic system model. Section 3 explores the proposed, adaptive, multiparty session management giving some requirements and providing a detailed description of how adaptivity is enabled in the proposed session management scheme, focusing only on multicasting as a service. Finally, Section 4 offers some conclusions.

2 Motivation

2.1 Context in Networking

In the last years, the sensor area has been widely developed opening the doors to a world where everything is sensed. There are sensors for almost everything: movement

detectors, temperature measurements, raining detectors. The information made available by the sensors allows building models to be used by context-aware systems. The definition of context, in a broad sense, could be the set of information used to improve the efficiency of a system. Therefore, a context-aware system processes context information in order to perform its tasks in a more accurate way.

Nowadays, there is already a link between context and mobile systems. A large number of services utilize user context information in order to deliver more accurate information to the end-users. Typical examples are location based services, such as "find the nearest pharmacy" or "where am I?" But more complex services are already planned. The use of mashups, i.e. the integration of simple services to give compound, more powerful ones, is useful to create innovative services linking different worlds making them personalized through the use of context information.

An important use of context information is that it allows the creation of communities that are looking for the same information, making them appropriate candidates for the use of multicasting. Such examples could be: users inside a museum demanding the same informative content or people in the train station that need the same schedule information. Based on the users' current situation, the mobile system requires mechanisms to create multiparty sessions to enable effective content delivery to users. For that, session management that supports the establishment of context aware multiparty sessions in a heterogeneous environment is needed

So far, session management has been an autonomous process, well separated from the context, even for sessions carrying context-aware services. Certainly, session management has not been using context information for improving the connections of the multiparty sessions. An enhanced session management functionality, smart enough to select, for instance, the appropriate media coding for a set of users, or use environment noise measures to increase or decrease the audio quality, is proposed in this paper. The authors address this enhancement by using users' situation information in order to provide more intelligent sessions for mobile communities.

2.2 Adaptive Multicasting Service Scenario

In the following scenario we illustrate how the eTourism and eAdvertisement industries may be enhanced, by offering context-aware, adaptive multicasting options to a mobile customer. Most of the available mobile applications are based on a pull transmission model where the unicast mode is used. Context-aware content delivery based on users' needs and using multicast capabilities are currently not considered in the mobile network due to limited interaction with user environment and lack of content description. Taking context information into account, the mobile targeted advertisements for the user might create new revenues.

The scenario's main objective is the context-related content provision during a tourist stay. Alex is visiting Berlin and subscribes for a tourist service during his stay. When walking through the city, he passes by a lot of interesting sights. He has the option of viewing video clips about the sights (he has already indicated in his profile that he is interested in watching such videos). Alex is part of a group of users that have subscribed to the tourist service. At each tourist site that Alex visits he becomes part of the group of a subset of subscribed users that, due to their current location, will watch a particular film. The video is multicasted to each such group; context is

location in this case. Alex and the co-located tourist group may be also informed of good restaurants and coffee-shops in the area. For this kind of information, context could be the time of day (e.g. lunch) and the current weather (e.g. propose a garden café only if it's sunny). Furthermore, since Alex's favorite food is pizza (indicated in profile) he gets a detailed list of pizza places, while other members of the group don't. Profile information is thus used for adaptive multicasting.

After Alex tries one of the nearby pizza places, he publishes recommendations and tags this content. The rest of the group is notified about the available multimedia contents which are created by Alex, one of the group members, as well as of contents by any professional or amateur content provider. According to the popularity of the content, several copies are distributed within network elements for further enquiries.

Moving on to a different tourist site, Alex notices that the sunny sky is slowly replaced by grey clouds. At that point, he receives an advertisement on his mobile phone about umbrella shops nearby shortly before it starts to rain. Environmental information like weather forecast and also location information create context-aware space around the user. The advertisement clip is then delivered to the user in addition to some location information where to buy this umbrella (including maybe also a discount depending on the type of contract – premium vs. limited contract). Alex starts running towards the umbrella shop, and automatically the quality of the video he was watching was decreased by the system. This happened because the system has sufficient intelligence to know that a user moving is not able to completely enjoy high quality videos and thus the system achieves the saving of some resources.

The tourist stay of Alex in Berlin has been enhanced by tourist information available "automatically" just by subscribing to the multicast service. He has received and offered content, sometimes personalized, about such locations as tourist sites, restaurants and coffee shops, by being made part of a multicast group that shared similar characteristics (e.g. location) and has subscribed to the service. Furthermore, Alex has received context-aware advertisement that has proved very helpful because it was immediately usable. Alex's connection, i.e. his session, needs to be managed in an enhanced way to achieve the above scenario. The subsequent sections will describe in detail how such session management is achieved.

2.3 Related Work

There are currently a few initial solutions touching the session management issues we are facing. In the deliverables D4.x of EU FP6 C-MOBILE a converged, multi-bearer service architecture that supports broadcast and multicast services is defined. The architecture defined in C-MOBILE project already makes use of context information as input for the group creation.

The work carried out in [1] addresses the impact of context, sensors and wireless networks in the telecommunications field. Several scenarios are proposed highlighting the possible synergies between the defined areas.

The authors of [2] propose a Point-to-Multipoint session management scheme using Session Initiation Protocol in MPLS-based Next Generation Network service stratum. This scheme is simple and flexible to join, modify, and leave session for NGN multicast service.

Paper [3] proposes and develops a new mechanism that supports Web services session management by using SIP. This means adding session information in the SOAP header element and using SIP to manage the session state for Web services.

The dissertation thesis of [4] forms a view on a group and session management system for collaborative applications. This thesis describes a system which provides designs of collaborative applications with group and session management functionality that can be used to easily build group communications.

The paper [5] describes a framework for managing connections to mobile hosts in the Internet. The framework integrates the notions of quality of service management and mobility management and forms a base for overall session management. The work acts on IP level and covers mobility management of IP networked devices. The framework was designed with support for QoS management in mind and introduced a new semantic where open data streams are treated as being separate sessions.

The approach of [6] is quite interesting for our issues as it exploits strategies involving the use of contextual information, strong process migration, context-sensitive binding, and location agnostic communication protocols for as they call it "follow-me" sessions.

2.4 Generic System Model and Open Issues

System elements and their dependencies are identified in Fig.1. Identified are the 5 key tasks to solve. This is not an architectural approach specifying core components but instead a general functional representation of the system, concentrating only on necessary system level functionalities.

- Publishing & Discovery
  - The content provider needs to have an interface to the content management of the infrastructure to publish and announce available content.
  - The content management needs to define mechanisms to discover available content.
- Sensing
  - The context management needs to define an interface for the global space to store sensed context information.
- Triggering
  - The infrastructure needs to have mechanisms to invoke or trigger the content delivery to the end users (content consumer).
  - This mechanism is represented by the session management proposed in this paper.
- Retrieving
  - The content delivery may obtain the available content either via pull mechanisms or the content provider pushes the content to the content delivery plane.
- Relaying
  - The content delivery is relayed to the content consumer.
  - This is done via multicast in this paper.

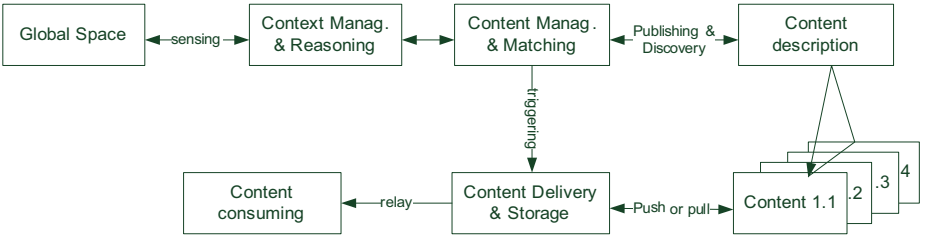

Fig. 1. Generic System model illustrating data flow between functional elements

There are two key issues of context-aware, adaptive multicasting:

(a) Context-to-content matching and,
(b) Session handling based on context information.

We consider issue (a) to be out of scope for the current paper, which concentrates on (b), the session enhancement. The generic system model of Fig.1 presents the data flow between the functional elements participating in a context-aware adaptive system and representing only the necessary functionalities. The model reflects both key issues, respectively in the system elements 'Content Management & Matching' and 'Content Delivery & Storage'. The session management is the logical entity between these two elements named 'triggering' in Fig. 1. This triggering requires an enhanced functionality handling the content-to-user relationships, which must act not only on user but also on context input. We specify this functionality to be the Session Manager entity and the central theme of this paper

3 Defining an Adaptive Multiparty Session Management

3.1 Context-Aware Session Management Overview

Session management is a core functionality of the context-aware, adaptive system. State-of-the-art includes several views on the topic, however, it does not address the participation of session management within a context-aware framework (apart from [6] which is more concentrating on ad-hoc networks) where the session management is required to handle context changes that act as triggers for session setup, renegotiation, termination or mobility. Such context could be identified as: (a) Network Context (e.g. available bandwidth), (b) Device Context (e.g. supported coding options) and (c) Environment Context (e.g. user preferred device per location). All these could effectively trigger a session to adapt. Specifically, we may summarize that context-aware session management for adaptive multicasting must be able to support the following functionalities

- Recognize a context trigger for session setup
- Recognize a context trigger for session renegotiation
- Recognize a context trigger for session termination
- Recognize a context trigger for session mobility
- Make additional requests for context when necessary to the appropriate functional entity

3.2 Technical Requirements

With respect to Fig. 1 we move on to describe the main functionalities of the enhanced session management entity. The first requirement is to decide which type of context information is useful for session management. There is an infinite set of context data, from the network to the environment, and not all of them are useful for improving the session management functionality. Consequently, it is mandatory to narrow down the wide variety of and in turn, it is required to define ways to accept the selected context information, which can come from either the network or from the environment.

The system is initially activated by a specific application, which supports context-awareness. Such an application should trigger upon activation a subset of at least the environmental context. Once the application is activated, the Content Management & Matching will provide an identification of the participating group of users requesting a specific content. Session management will carry this group id to the Content Delivery & Storage entity and receive some information describing the specific content (e.g. media, codec, maximum bit rate).

Based on this information the user group will be adapted based on the context of the users. The users in the group will be checked for common network characteristics (in a heterogeneous environment users in a group may not be served by the same access network). The decision of which network is selected for a specific user may affect the setup of the session, e.g. bandwidth limitations of the selected network may affect the selection of content coding. Therefore, the session management is notified upon a network change to renegotiate the session in question effectively. Furthermore, the session management may request the network information for a specific user for initial session setup.

Other than the network change, session management needs to be able to accept triggers regarding additional environmental changes, or even be able to make request for user information like the user profile. Such information may include coding options supported by the user device (e.g. resolution, coding options supported) or even desired by the user based on user profiles and further information that have to do with the environment (e.g. user preferred device per location or even more dynamic information such as movement, proximity and others). Once the users can be characterized, the session management sets up a different session for each subset of users that demonstrate similar context characteristics. Each session for a specific sub-group of users includes appropriate media attributes and it is sent back to the Content Delivery and Storage entity in order to receive the appropriate content.

This is an important interface from a functional perspective as it needs to be clearly defined for the appropriate content to reach the content consumers, based on the users' context and capabilities. The adaptivity is enabled by the sub-grouping activity of the Session Manager described in more detail in Section 3.3.

3.3 Adaptivity in Session Manager: Forming Subgroups

A key issue within the enhanced session management involves the study of the most efficient way to make decisions regarding subgroups based on the context information

discussed previously. For this, we must consider the information available through the interface to the adjacent entities, specifically the session management needs to be able to:

- Translate obtained context information into descriptions of content substreams;
- Communicate the descriptions of the required streams in terms of content delivery recognizable parameters;
- Receiving & Handling the requested stream.

A lot of emphasis must be given to the interface between the session management and the Content Delivery & Storage. For example, in the case of video, parameters that need to be considered in this communication are quality preferences, device capabilities and bandwidth that will describe the required stream based on the subgroup decision. The subgroup decision will be based on more criteria including the acquired context information but will be translated into a media description appropriate for the particular session.

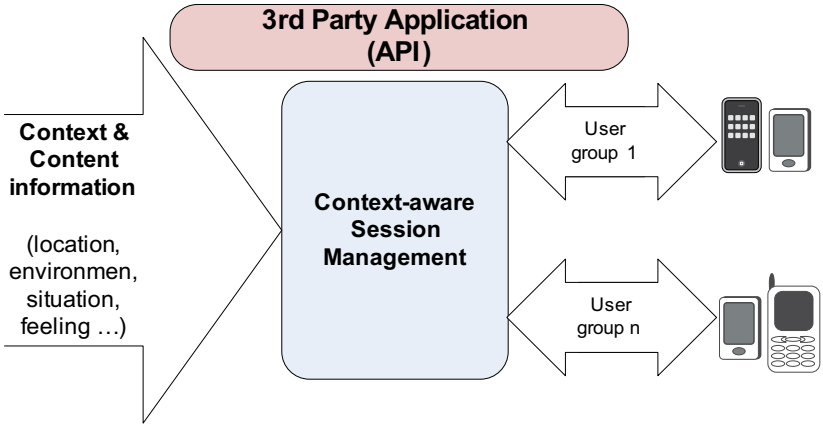

Fig. 2. Logical representation of sub-grouping based on context

In order to achieve efficient subgrouping, the Session Manager must successfully handle three interfaces:

(a) The interface between the network and the SM,
(b) The interface between the Content Management & Matching and the SM,
(c) The interface between the Content Delivery & Storage and the SM

For interface (a) the requirements have to do with transmission quality in terms of ensuring that the network has enough resources to make the transmission effective without any quality losses. For this requirement the SM needs to know the access network assigned to a user as well as the network's capabilities. We assume that the network has the capability of providing intelligent context-aware network selection. Therefore, a multimode terminal will always receive multiparty sessions using the

best network interface at the time. Furthermore, the specific capabilities of the selected access network may be acquired by SM through its interaction with the network.

For interface (b) the SM considers context information additional to the network information exchanged in the Network-SM interface, such as location, profile information or terminal capabilities. This kind of information is made available at the Content Management & Matching entity through the Context Management and reasoning functional entity, which acts as a repository of context information available to any entity acting as a context consumer (e.g. the SM).

This brings the discussion to the next set of requirements mentioned in (c). For this interface the SM does not receive information as in (a) and (b) but instead, once it receives the group id from the Content Management & Matching entity, it sends it to the content processor, to receive back appropriate content information that aids in forming the network sub-groups. Once the sub-groups are formed a session for each is opened and a set of media parameters directly related to the specific sub-group and describing a content stream is sent to the Content Delivery & Storage entity in order to receive the content stream adapted for a specific sub-group. A subgroup may be defined by such parameters as content id, resolution of user terminal screen, codec, access network and available bandwidth, whereas a requested content stream may be defined by such parameters as content id, codec, resolution of user terminal screen and maximum data-rate, making the mapping of parameters almost trivial.

Finally, since a multi-access network environment implies heterogeneity, a generic networking service should be available to establish QoS-aware multiparty sessions over heterogeneous networks, i.e. whenever SM needs to manage a multiparty connection, it will use the service provided by the multiparty transport layer in order to setup the desired connection.

3.3.1 Specifying Context-Aware Multiparty Session Establishment for Adaptive Multicast Sessions

The key functionality of the SM is to create network subgroups based on network information as well as general user & environment context information to the extent that these are considered necessary for forming network groups, and in turn communicating the characteristics of these subgroups in the form of content stream descriptions to the media delivery function for obtaining the appropriate content for each subgroup. To achieve this task it is a key requirement to have effective interfaces between the SM and the entities that provide input parameters to the SM as well as the entities that receive output parameters from the SM since the success of subgroup forming and receiving the content is gravely dependent on these communications.

Fig.3 illustrates Context-Aware Multiparty Session Establishment using generic terms for functional entities as used in Fig.1, as well as throughout the description. The flow diagram clearly indicates the sequential interactions and communications between the functional entities that interact with the session management and further indicates the sub-grouping process responsible for achieving adaptive multicast sessions. Once the users register for a service (Step 1), they become context providers to the Context Management & Reasoning entity (Step 2). Simultaneously, the application provides the users registered for a service to the Content Management & Matching entity (Step 3). Once the multicast groups are built, the relevant information

is communicated to the Session Manager as indicated in Step 5, at which point the Session Manager passes this information to the Content Delivery & Storage entity, which is responsible to match the group information to a specific content (Step 6). After obtaining the content description, the Session Manager contacts the network monitoring entity to get network-specific information (Step 7) as well as the Context Management & Reasoning entity to get user context & profile information that will help in forming more efficient user subgroups (Step 9). Once subgrouping is done, the user sessions are established (Step 10) as well as the media sessions (Step 11) and the media is delivered to the users (Step 12).

A good candidate protocol for specifying the interfaces to the SM both for input and for output is Session Initiation Protocol (SIP) [8]. SIP (together with Session

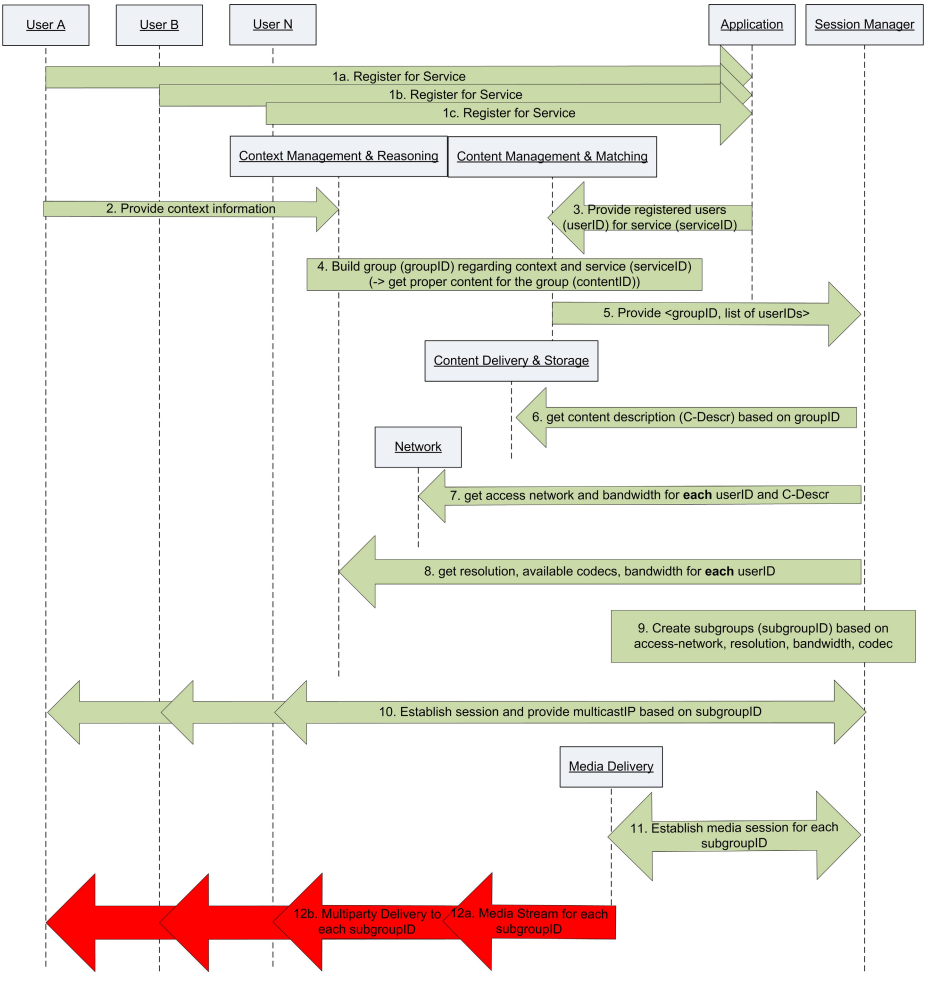

Fig. 3. Context-Aware Multiparty Session Establishment

Description Protocol (SDP) [9] for more elaborate session description) provides an access agnostic means of communication between different entities by providing a specification for application-level control signaling. SIP is an open stateless signaling protocol defined by RFC 3261 used for creating, modifying, and terminating multimedia communication sessions between user endpoints (SIP User Agents) to agree on a characterization of a session they would like to share. SIP works independently of underlying transport protocols and without dependency on the type of session that is being established.

SIP supports five facets of establishing and terminating multimedia communications:

- **User location:** determination of the end system to be used for communication;
- **User availability:** determination of the willingness of the called party to engage in communications;
- **User capabilities:** determination of the media and media parameters to be used;
- **Session setup:** "ringing", establishment of session parameters at both called and calling party;
- **Session management:** including transfer and termination of sessions, modifying session parameters, and invoking services.

SIP acts as a carrier for the Session Description Protocol (SDP), which describes the media content of the session. In typical use, SIP "sessions" are simply packet streams of the Real-time Transport Protocol (RTP). RTP is the carrier for the actual voice or video content itself. SIP is similar to HTTP and shares some of its design principles: It is human readable and request-response structured. SIP supports the Offer/Answer model of RFC 3264, where one participant offers the other a description of the desired session from their perspective, and the other participant answers with the desired session from their perspective.

4 Conclusions

The world is experiencing a revolutionary transformation. The worldwide spread of sensors allows augmenting the reality interpretation. The context information made available by sensors may be used to improve the efficiency of a system. Such efficiency is already being added to the mobile industry since the usage of context information to deliver content in a more accurate manner is becoming more and more popular. Location-based services are disseminated all over the world.

In addition, the use of context allows the definition of mobile communities that are characterized by requiring the same content. The users in similar situations should receive the same data. The mobile system, and specifically multicasting, should be enhanced to create multiparty sessions that allow content delivery to such groups of users. Session management provides the necessary signaling to deliver a specific content to its consumers, handling different types of events regarding session control. Session management thus participates in dynamic changes such as switching between different content.

The work presented here addresses this kind of dynamic session, i.e. a multi-party session that may respond to context changes in order to adapt and satisfy the users of a group. By using the user's situation information, the paper illustrates ways to provide more accurate sessions for mobile communities. An evolved Session Manager functional entity is described supporting the establishment of context aware multiparty sessions in a heterogeneous environment in an efficient way.

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