Context Transfer Extension to Mobility Protocols for All-IP Based Infrastructures

M.Georgiades, K.Chee, C.Politis, R.Tafazolli
Center for Communication Systems Research (CCSR) University of Surrey Guildford, GU2 7XH, Surrey, UK
{m.georgiades, k.chee, c.politis, r.tafazolli}@surrey.ac.uk

Subject Area: WG3 - New Communication Environment and Heterogeneous Networks

1. Objectives of the required research

Making handover seamless is one of the key issues in mobility management for next generation all-IP networks. It is important to note that in the next few years the majority of terminals will be mobile and the majority of traffic will originate from IP-based applications offering more and more real-time services. The quality of real-time services like VoIP telephony and Video on demand will depend greatly on the ability to minimize the impact of the handover, hence traffic redirection of ongoing sessions.

“Context Transfer” aims to contribute to the enhancement in handover performance. When a mobile node (MN) moves to a new subnet it needs to continue certain transport- or routing-related services that have already been established at the previous subnet. Such services are known as ‘context transfer candidate services’, and examples include header compression, QoS policy, AAA profile and IPsec state. Re-establishing these services at the new subnet will require a considerable amount of time for the protocol exchanges and as a result time-sensitive real-time traffic will suffer during this time. Alternatively context transfer candidate services state information can be transferred, for example, from the previous access router to the new access router so that the services can be re-established quickly (see Figure 1). A layer-3 context transfer protocol will result in a quick re-establishment of context transfer candidate services at the new domain. In addition, operating at layer-3 ensures interoperability among layer-2 radio access technologies. It would contribute to the seamless operation of application streams and could reduce susceptibility to errors. Furthermore re-initiation to and from the mobile node will be avoided hence wireless bandwidth efficiency is conserved.

This work acts as a compliment to the work presented in [1]. It is also an important component of what we call Multilayer Mobility Management in the IST EVOLUTE project. The main focus of this research is to investigate ways in which this Multilayer Mobility Management scheme could be enhanced with a context transfer mechanism aiming to contribute to the overall objective towards seamless mobility in next generation's all-IP networks. Below is description of some network-related services, which are possible examples of context transfer candidate services.

AAA - Authentication, Authorization, and Accounting (AAA) is a framework for controlling the access to computer resources, enforcing policies, inspecting usage, and providing the information required to bill for services. The time consumed by AAA transaction may affect the handoff latency and consequently affect the ongoing sessions. During the handoff, the interactions between mobile node and AAA servers need to be avoided. Context transfer could facilitate this by forwarding the AAA related information from the previous to the new access router.

QoS - QoS is of particular concern for the continuous transmission of high-bandwidth video and multimedia information. Establishing the initial QoS between a mobile node and routers in the network would require a significant number of message exchanges. Judging from existing QoS mechanisms such as DiffServ and IntServ, re-establishing the initial QoS between the mobile node and the new access router could be very time consuming. This is
undesired and a protocol like context transfer could greatly facilitate such a service. The mobile node’s QoS context
could be forwarded from the previous access router to the new access router in the new subnet thus avoiding the
message exchanges between mobile node and router for reinitiating the QoS at the new delivery path.

**Header Compression** - Real time applications in wireless environment face the problem of large packet overhead,
especially for IPv6, thus header compression is required. A number of header compression schemes have been
developed by IETF. These compression schemes in general require from 1 to 4 exchanges between the last hop router
and the mobile node before full compression takes place. Before these procedure completes, the header information
sent over the radio network link still remains uncompressed. Context Transfer could be used to supply the new access
router with the compression context used at the previous router.

![Context Transfer in All-IP based infrastructures](image)

Figure 1: Context Transfer in All-IP based infrastructures

Other possible context transfer candidate services may include: **Multicast group membership** where the AR must
know which multicast groups the mobile has already joined; **IPsec state** where the AR may act as an IPsec gateway,
in which case a security association between the mobile and AR enables packets to be encrypted and decrypted
between the two.

## 2. State of the art in the area

Previous research related to enabling seamless mobility over IP infrastructures focused mainly on enhancing the
handover procedure between access routers or base stations. The research community has also now begun to consider
access router discovery and context transfer. Currently there is much active discussion at the IETF’s SEAMOBY
working group [3], aiming towards a protocol which would allow state information to be transferred between edge
mobility devices [2][4]. A number of Internet Drafts have been written proposing a context transfer protocol, defining
a framework of control structures that enable authorised context transfers [5][6][7].

For this research, we are aiming to design and develop a context transfer scheme for a multilayer mobility
management infrastructure, an environment which differentiates between the different kinds of mobility. Namely, a
separation is made between global mobility (also referred to as macromobility), which describes the movement of end
systems between subnets and local mobility (also referred to as micromobility), which describes the movement
between neighbouring stations. More specifically the following mobility protocols will be considered for extension
with context transfer capabilities:

- **Mobile IP** (Macromobility protocol) [8]
Hierarchical Mobile IP (Micromobility tunnel-based protocol) [9]
Cellular-IP (Micromobility host-specific forwarding protocol) [10]

These mobility protocols will be extended to offer extra functionality for forwarding the desired state information to the new access router.

3. Possible approach

Context Transfer extension to Mobile-IP (Macromobility protocol)

As a MN moves from one (sub)network to another, after establishing a link-layer connection at its new network, it sends a Binding Update (BU) packet to a foreign agent (FA) and its Home Agent. This is in fact a handoff process at the IP layer. Since its HA may be located far way from the MN’s current point of attached, we do not consider making use of the HA while designing the context transfer operation. The closest entities involved are the MN, the previous FA, and the new FA. However, there is no message exchange taking place between the previous FA and the new FA, as specified in Mobile IP. Hence, explicit signalling is required for the new FA to request feature contexts from the MN’s previous FA.

Figure 2 depicts a basic context transfer operation in Mobile IP. Upon receiving a BU packet from the MN, the new foreign agent sends a Context Update Trigger (CU-Trig) message to the previous foreign agent of the MN. The MN's previous foreign agent responds with Context Update Data (CU-Data) message, in which requested feature contexts of the MN is provided.

![Figure 2: Basic CU operation in Mobile IP](image1)

![Figure 3: CU operation in Mobile IP for fast handoffs](image2)

The context transfer procedure described above may be sufficient because if Mobile IP is applied for handling mobility of MN across networks (macro-mobility), which is usually not as frequent as mobility across access routers or base stations, the handoff performance may be relaxed. However, for fast handoff and truly seamless handoff performance, a proactive approach is preferred. Figure 3 shows signaling sequence of a fast handoff version of a context transfer operation in Mobile IP. Here, it is assumed that MN is able to anticipate a change in network, and hence a handoff, as well as to acquire information on the new foreign agent. MN sends a Context Update Trigger (CU-Trig) to its current FA (which would become previous FA) prior to sending Mobile IP binding update to the new FA. Such CU-Trig message provides necessary information to the MN’s current FA, and activates the FA to forward context information to the MN’s new FA. The context transfer operation is likely to be carried out at the same time as the BU operation, since the MN may send the BU packet at any time after CU-Trig is sent to its previous FA. Performing context transfer prior to handoff operation certainly promises better handoff performance. If it is carried timely, the services used by MN at its previous network may be continued without any interruption.

Context Transfer extension to Hierarchical Mobile-IP

Hierarchical Mobile IP introduces the Mobility Anchor Point (MAP) as a local entity to assist with Mobile IP handoffs. The MAP reduces the amount of signalling required outside the local domain and also supports Fast Mobile
IP handoffs [11] to assist the mobile nodes in achieving seamless mobility. When a mobile node changes access points within a MAP domain only a single local Binding Update (BU) is required with the MAP. This minimises latency in comparison to Mobile IP where two BUs are send to MN’s correspondent node and to the home agent. As with Mobile IP the mobility solution is independent of the underlying access technology. Thus the interoperability issue, which is required for context transfer, between the different types of access networks is already taken care of by the mobility protocols.

When the mobile node changes access point within a local MAP domain it only registers its new local care of address with the MAP. The global care-of address which is already registered with the corresponding nodes and the home agent does not change. Therefore when the mobile node does a local handoff, it sends a BU to inform the MAP of its new local care-of address. What we propose is to use the BU packet as a trigger to initiate authorised context transfer from the MAP to the new access router (see Figure 4). MAP could be used as a central entity to store the context information and would download this to new access router, using a context update (CU) packet, on reception of a BU packet.

![Figure 4: Hierarchical Mobile IP with additional signaling to support Context Transfer](image)

**Context Transfer Extension to Cellular IP (per-host forwarding micromobility protocol)**

The research also aims to enhance Cellular-IP (CIP) mobility protocol with a Context Transfer mechanism aiming to optimise the handoff operation in mobile networks. Within a Cellular-IP domain, during handoff from one base station (BS) to another, Cellular-IP packets could be used to initiate, and possibly transfer, authorised context from the previous base station via the Cellular-IP gateway (CIP-GW) to the new base station. The context information is pre-stored in the CIP-GW and a copy of this context (state information) will be forwarded to the new base station (NBS).

One of the main advantages of using Cellular-IP is the distinction it makes between idle and active mobile nodes. This separation allows the network to track mobile nodes that are in active state and deliver packets without searching for the mobile nodes. By maintaining separated caches for active and idle mobile nodes, a smaller cache is searched for packet delivery and this results in faster lookups and better scalability [10]. This separation of active from idle nodes is also beneficial to the context transfer mechanism, since the fundamental intention of context transfer is to maintain network-services of active mobile nodes.

In order to incorporate context transfer mechanism in Cellular-IP protocol the following enhancements are required:
Handoff is initiated from the mobile node by sending a route-update packet towards the Cellular-IP gateway (see Figure 5). When an active node connects to a new BS, it transmits a route-update packet to CIP-GW. The route-update packet will update Route Caches in nodes along the way from the NBS to the CIP-GW. We introduce a new flag, called H (handoff) flag, in the route-update packet. When the route-update packet reaches the CIP-GW, if the H flag is enabled, the CIP-GW will send a context-update packet towards the mobile node. The context-update packet, carrying the feature contexts, will be routed along the reverse path on a hop-by-hop basis towards the mobile node. When the context-update arrives at the NBS, the NBS stores the context data in its context cache and it discards the packet.

**Semi-soft handoff in Cellular-IP**

One of the extensions proposed in [10] aims to improve the performance of loss sensitive applications by introducing another type of handoff called "semi-soft" handoff. The handoff procedure described above is known as "hard" handoff and is where the mobile node switches from the PBS to the NBS all at once. With "semi-soft" handoff the mobile node maintains communication with the PBS while establishing connection with the NBS. Packets intended to the mobile node are sent to both Base Stations, so when the mobile node eventually handoffs it continues to receive packets without interruption [10]. The mobile node initiates the semi-soft handoff by sending a route-update packet with the S flag set to 1 towards the CIP-GW via the NBS while continuing to listen to the PBS. This handoff procedure will not only result in a smoother change over between base stations but it is also favoured by the context transfer extension since it provides us with a context transfer trigger (route-update packet) prior to handoff. If the context transfer procedure completes before the mobile node attaches to the NBS, the NBS will have a copy of the desired state information prior to handoff and consequently this will be the ideal case.

4. Expected results

The context transfer operation described above will be further studied in more detail. The dependency and interoperability between context transfer protocol and handoff protocols will be investigated. The mobility management-related protocols being considered are Mobile IP, Hierarchical Mobile IP and Cellular-IP. Initially existing packet formats defined by the mobility protocols will be investigated to check whether they could be utilised.
as carriers for context transfer or as triggers to context transfer. Any information to be extracted (which may be required by the context transfer protocol) from the existing messages of the mobility protocols will also be identified. If required we may need to extend the packets used by the mobility protocols. Finally, we may need to introduce additional packets to carry or trigger context transfer. All these possible options will be investigated in order to identify an optimum context transfer solution for each of the mobility protocols, with the primary concern of avoiding extra load on the signalling used for handoff itself.

In order to evaluate, as well as to refine, the proposed context transfer operation, network modelling and simulation will be carried out. The choice of simulation tool is OPNET. Both macro- and micro-mobility scenarios will be modelled, that includes Mobile IP, Cellular-IP and HMIP. The evaluation would use a model which simulates a baseline scenario for each of the mobility protocol mentioned, whereby no context transfer is implemented as yet. It would then be extended to incorporate the appropriate context transfer enhancement. The timeliness and hence the effectiveness of performing context transfer during a handoff will be measured and compared among the possible options. Other criteria in choosing the optimum context transfer solution will include the amount of signalling involved by the extension and the extra load added to the handoff.

5. Time Frame to get the expected results

Initial research results should emerge in the third quarter of 2003.

Acknowledgements

This work has been funded by the IST-2001-32449 EVOLUTE project, which is funded by the European Union.

List of References