Multimedia Content Delivery in Wireless Environments

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Abstract

Multimedia communication through streaming is possible across wide range of network conditions due to the recent advancements in video and audio codec technologies. Because of the increasing trend for ubiquitous connectivity more and more areas have overlapping coverage of wired and wireless networks. Because the user has an option to choose the best service to get the best performance for the multimedia application, the service needs to adapt to the changes in the network, computational resources as well as user movement. This paper describes and compares two different strategies for adapting to the changes in the network for multimedia media applications. The first strategy is to adapt to the changes in the network at the application layer, while the other strategy is to deal with the changes in the network at the network layer. This paper compares the two different strategies pointing out which one is better over the other and in what scenario.

1. Introduction

This paper compares two different strategies, which adapt to the changes in the network in different ways. One strategy is to deal with it at the application layer, i.e the applications are written in a way to deal with changes in the network i.e. they are aware of the changes in the network conditions. This paper describes two examples systems that deal with mobility at application level; the first one is a *self-adaptive distributed proxy system ([1])*. This system adapts to the real time network variations and hides handoff artifacts using application protocol specific knowledge. It also uses techniques like Forward Error Correction (FEC) and compression. The other example is to deal with mobility at the application level using a text based signaling protocol called *Session Initiation Protocol* **SIP** [2,3].
This is a application level protocol, which is used for establishing and tearing down multimedia sessions, both unicast and multicast. It has been standardized by the IETF for the invitation to multicast conferences and VoIP services.

The other strategy is to deal with the network changes for multimedia applications at the network level, as an example of this strategy, this paper describes a IP –Based Multi-tier Network for Mobile Multimedia Communication Services [5]. This system incorporates both cellular IP and Mobile IP, cellular IP is used to support mobility with in the domain, and Mobile IP is used to support inter domain mobility. Mobile IP allows mobile hosts to change location and reduce data packet loss probability in wireless communication networks. However, Mobile IP still has some defects in handoff and route aspects. Thus Cellular IP is proposed for routing of IP data grams to mobile stations and fast handoff control in a limited geographical area. It can cooperate with Mobile IP to provide wide area mobility support. This system also offers soft handoff method to improve Quality of Service and resource switching management to reduce data packet loss for mobile multimedia communication in Cellular IP and Mobile IP network.

The rest of the paper is organized as follows. In section 2 the Self Adaptive Distributed Proxy System [1], and Session Initiation Protocol SIP [2] are discussed. Section 3 describes the IP –Based Multi-tier Network for Mobile Multimedia Communication Services [5]. Section 4 gives the comparison of the two strategies, which is followed by conclusion.

2.1 Self-Adaptive Distributed Proxy

Overlapping coverage of wired and wireless networks is very common due to increasing coverage of networks, for example a mobile device may have access to a one or more networks such as the Ethernet Wave LAN simultaneously. Also there is a growing variety in the mobile devices like Pocket PCs laptops and cell-phones. Given these trends of increasing heterogeneity in terms of clients,

Services, codecs there needs to be infrastructure support for multimedia services in network to hide network and device heterogeneities .The Self-Adaptive Distributed Proxy [1] provides support for multimedia streaming to heterogeneous clients at application layer, it intelligently adapts to the network variations through passive monitoring of the application performance to optimize the user's experience. At the core of the proxy system is a middleware service called *Automatic Path Creation Service* (APC), which provides a platform for multimedia communication. The proxy system extends Vertical Handoffs [6] and Horizontal Handoffs [7] to handoffs across end devices, which include both of these handoffs as well as service session handoffs. A service session handoff occurs when a end user changes the mobile device to access the network service.

The authors in [1] argue that supporting handoffs at the link, network or transport level is not sufficient since they do not address the service session handoffs and they require support from the infrastructure, which may not be omnipresent in heterogeneous Internet.

APC provides smooth handoffs across IP address changes at the application layer as described later, this requires no changes in the network an transport layers, this is possible because it has control over the entire network path.

2.1.1Design Goals

- **Any to Any Communication:** Due to the wide range of capabilities **in** software, memory and display transparent access to services is an important goal.
- **Automated Data Format Adaptation:** The creation of the data path for the adaptation of the service content to heterogeneous devices should be automated. Negotiation between the devices and the service for selecting the type of the device to receive the service content and for device handoffs must be automated.
- **Seamless Handoffs across networks:** When users roam between different networks they change their IP addresses and enter a different coverage area, it is

therefore important to provide seamless handoffs while marinating the current sessions. When multiple networks are available in such a situation the selection decision should be made based on the metrics of overhead and quality of service.

- **Seamless Handoffs across Devices:** The user may need to handoff a device session to another set of devices. The proxy system supports policy based user preference driven handoffs across devices seamlessly.
- **High Quality of Service:** Real-time multimedia applications require low jitter, delay and guaranteed bandwidth, thus the proxy deploys various mechanisms to optimize performance.

2.1.2Self-Adaptive Distributed Proxy Architecture

Unlike traditional proxies the proxy system is defined and configured automatically, it dynamically adapts to resource variations and provides transparent client mobility support. The proxy system creates a application data path: a directed acyclic graph (DAG) of strongly –typed transcoding and optimizing oprerators. The creation of the data path is triggered when a client first initiates a connection to a service. This scheme doesn't require any change in the server software but requires a slight change in the client software since it needs to send control information for the service session, which is forwarded to the APC for the path construction. To achieve any to any communication between arbitrary client devices and multimedia services, the APC service compiles a DAG of transcoding operators for data transmission to address any mismatches. The path compilation consists of two steps logical path compilation and physical path compilation.

2.1.3 Logical Path Compilation: A logical path consists of a DAG operators with a single source and sink. To construct a logical path, the inputs to the APC consists of information like the data source, data sink (i.e. the client), location data format, data rate, available locations for operators, operator software, operators execution requirements, current network topology etc. Some of the information can be automatically discovered by the APC or by other infrastructure services such as Service Discovery Services [6].

2.1.4 Physical Path Compilation: After logical paths are determined their physical paths are determined next by APC, physical path s are nothing but a logical path with its operators determined. The operator placement strategies take into account network, server load information, properties of each operators and data flow, as well as workload characteristics. Operators in the path are placed such that end-to-end delay is minimized and operator execution criteria are satisfied. For a given logical path the APC may not find a physical path with acceptable performance due to resource constraints, thus APC may go back to the logical path compilation step.

2.1.5 Adaptation to Network load and Mobility.

Once the path has been established it can be modified during the runtime depending on the feed back from the monitoring agents collocated at each operator, the monitoring agents passively measure at each operator to gather information on throughput, delay variation and any other application specific anomalies to, if there is any anomaly then the agent immediately notifies the APC for path adaptation. The proxy system deploys both application specific and application independent adaptation.

Besides adapting to any resource changes another aspect is to adapt to path failures .APC provides mechanisms for both the path failure and operator failure. Path failure is detected through active probing and passive monitoring. Active probing occurs between APC and each operator's monitoring agent to detect failures at both the process and machine level. To achieve fast fault recovery partial path repair is always done before rebuilding the entire path.

During a service session if a user moves to a new network, the APC automatically manages handoffs for new networks, this occurs without user intervention, this is done by the client proxy that executes on the client device which monitors the availability of the network interfaces and signals the APC when changes occur. AS new devices become available service session handoff occurs automatically. The handoff decision across networks is policy driven.

2.1.6 Design and Implementation of APC: As a distributed middleware service, Automatic Patch Creation service is responsible for automatically creating, executing and maintaining the data path.

The Automatic Path Creation can be implemented in two ways: the BGP anycast mechanism and the DNS redirection technique. The BGP anycast mechanism has a well-known phantom IP address (eg 1.2.3.4) associated with the APC service. A redirector router is located in each APC service cluster, and it advertises BGP routes to this phantom address. The redirector is aware of all APC service instances in the network. When a client sends its first path creation request, the nearest redirector by the hop count metric intercepts the request and returns the physical IP address of the co-located APC cluster service.

The second scheme uses modified DNS servers, which contain information about the current load of a network distance to the APC service clusters. When a client sends a request to the well-known APC service domain name, the local DNS server translates the name to the least loaded APC service cluster with in close network proximity.

2.1.7 Sample Path Application

To validate the design the authors chose a scenario in which a wireless laptop is being delivered an MPEG-1 video/audio stream, it has both the Wave LAN and Ethernet interfaces. It is only capable of playing Real video and Real audio format.

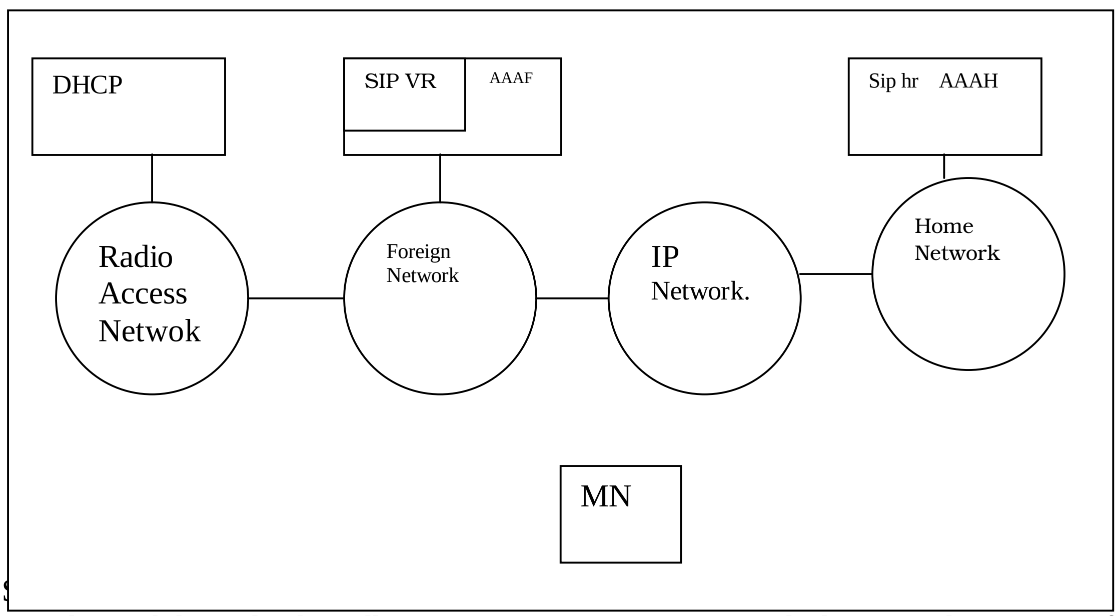
In this client because the end client cannot play MPEG we have to have a transcoder to convert MPEG to RealVideo.In APC we introduce a special type of operator called the redirection proxy. A redirection proxy is a very lightweight operator whose only purpose is to forward data from one socket to another. The server redirection proxy resides on any machine with a fixed IP address .Its job is to provide a fixed point of correspondence from the point of view of the server. The client side proxy sits on the same machine as the client application .The client side proxy binds to a well known port on the loop back

address (127.0.0.1) so that its IP address remains valid across all IP address changes during roaming.
On client side a small program constantly monitors for available network interfaces for available network interfaces. When the APC detects that the IP address of a client has changed it notifies the client proxy to connect to the server side proxy using the new IP address.

2.2 Supporting Mobility in Multimedia Applications Using SIP.
Sip is an application layer protocol used for establishing and tearing down multimedia sessions both unicast and multicast [2].The SIP user agent has two functions [2]

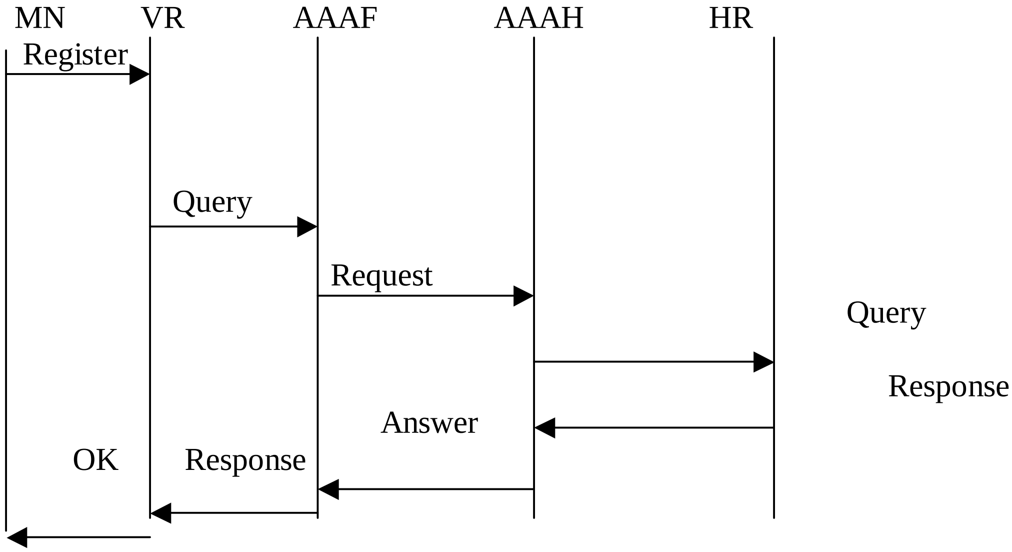
- Listening to the incoming SIP messages.
- Sending SIP messages upon user actions or incoming messages.

The SIP proxy server relays SIP messages so that it is possible to use a domain name to find a user rather than knowing the IP address. Thus SIP can be used to hide user location [4]. In [3,4] the approach is to have a combination of SIP, DHCP, and an AAA protocol. This approach supports domain handoff i.e. movement between different administrative domains as well as domain hand off i.e. movement between subnets that belong to the same administrative domain.



MN is the mobile node that allows users to communicate and also provides means of interactions and control between users and the network.
Radio Access Network provides wireless access to the MNs.

The MN uses DHCP to configure itself, and the foreign network also uses DHCP as in [4], the MN broadcasts a DHCPDISCOVER message DHCP servers. Several servers offer address to the MN via the DHCPOFFER that contains the IP address, address of default gateway, subnet mask etc. After the MN is assigned an IP address from the DHCP server the MN will begin the signaling flow for SIP complete registration as depicted below.



First the MN sends a SIP REGISTER Message to the VR with its new IP address; this is done through the SIP proxy Server Address obtained from the DHCP messages. The VR queries the AAA entity (Authorization, Authentication, Accountability) .The AAAF entity of the visited network queries the AAA entity (AAAH) of the home network to verify MNS credential sand rights. The AAH queries the HR and depending on the response from the HR it sends a response to the AAAF.

After this registration the MN can initiate a SIP session by sending the INVITE message to the callee. Then the cal lee responds with a 200 ok message. An Example of a SIP message is as follows

REGISTER MN --> SIP Server (Registrar)

REGISTER sip: reg.home.com SIP/2.0
Via: SIP/2.0/UDP venus.home.com: 5060
From: Alice <sip: Alice@MS.home.com>
To: Alice <sip: Alice@MS.home.com>
Call_ID: 82946@venus.home.com
Cseq: 1 REGISTER
Contact: Alice@10.12.14.16; expires 3600,
Alice@10.8.3.243; expires 0
Content Length: 0

200 OK SIP Registrar --> MS

SIP/2.0 200 OK

Via: SIP/2.0/UDP venus.home.com
From: Alice <sip: Alice@MS.home.com>
To: Alice <sip: Alice@MS.home.com>
Call_ID: 82946@venus.home.com
Cseq: 1 REGISTER
Contact: Alice@10.12.14.16; expires 3600
Content Length: 0

The above figure of SIP signaling mechanisms indicates that a complete registration with the visited network takes a roundtrip delay. In order to avoid this the strategy proposed in [4] is called the shadow registration, the key idea is that the Security Association (SA) between the MN and the AAA server in neighboring domains is established a priori before the actual handoffs occur. Thus when a MN hands off to a neighboring domain the registration request is processed locally within the domain without going all the way to the MN's AAAH.The pre establishment of the SA can be done in a distributed manner where the given AAA server directly contacts the neighboring AAA servers.

3.IP Based Multi-tier Network for Mobile Multimedia Communication Services:

This system incorporates both cellular IP and Mobile IP, cellular IP is used to support mobility with in the domain, and Mobile IP is used to support inter domain mobility. Mobile IP allows mobile hosts to change location and reduce data packet loss probability in wireless communication networks. However, Mobile IP still has some defects in handoff and route aspects. Thus Cellular IP is proposed for routing of IP data grams to mobile stations and fast handoff control in a limited geographical area. It can cooperate with Mobile IP to provide wide area mobility support. This system also offers soft handoff method to improve Quality of Service and resource switching management to reduce data packet loss for mobile multimedia communication in Cellular IP and Mobile IP network.

In this architecture the Internet is considered as overlapping hierarchical network. Each framework has its individual feature, i.e satellite, macro-cell, micro–cell, and Pico cell area.

The cell ranges are as follows:

- Mega cell: provides a wide overlay area and is used in a location, which has the lowest communication, communication range between 100 –500 km.
- Macro cell: provides a big overlay area and is used in a location, which has the lower communication; communication range is smaller than 35km.
- Micro cells: provides for low mobility area and is used in a location, which has higher communication, communication range is smaller than 1km.
- Pico-cell: it is used in indoor mobility area and is used in a location, which has the highest communication, range less than 1km.

3.1 Overview of Mobile IP and Cellular IP

3.1.1 Mobile IP: Mobile IP defines three main functional entities.

Mobile Node (MN): A node, which can change its point of attachment to the Internet from one link to another while maintaining any ongoing communications and using only its home address.

Home Agent (HA): A router with an interface on the mobile node's home link which a mobile nodes keeps informed of its current location, as represented as its care-of-address, it intercepts packets destined to the mobile node's home address and tunnels them to mobile nodes current address.

Foreign Agent (FA): A router on the mobile node's foreign link which assists the mobile node in communication with its home agent of its care-of –address, it also provides the care-of-address in some cases, and detunnels packets for the mobile node that have been tunneled by its home agent.

Home Address: The address assigned to the mobile node by home network manager, doesnot change from link to link.

Care-of –address: The IP address associated with the mobile while it is visiting the foreign network.

Registration: while mobile node moves to a foreign network it must register to home agent to get a temporary care-of-address.

Mobile IP Message flow: When a mobile node (MN) moves form home network to foreign network, foreign agent (FA) will send an advertisement message if any MN exists in will send a registration request message through FA to home agent (HA). After the Home Agent replies with a registration reply message the registration is successful and the FA gives the MN a temporary care of address. After this all the nodes send data at the Home Agent of the MN, which will add FA's address (encapsulates) to packets and transfers to FA.

3.1.2 Cellular IP: Cellular IP [7] represents a new mobile node protocol that's optimized to provide access to a mobile IP enabled Internet in support of fast moving wireless nodes. It can offer fast handoff, less delay, a few or even no packet loss between base stations.

In cellular IP, location management and handoff support are integrated with routing. To minimize control messaging regular data packets transmitted by mobile nodes are used to refresh node location information. Paging is used to route packets to idle mobile nodes in a Cellular IP network. Routing is an important entity in Cellular IP a routing cache is used in a base station to store mobile node's path. Route update packets keep mobile nodes routing cache mapping valid.

Cellular IP supports two types o handoff schemes. Cellular IP hard Handoff is based on the principle that trades of some packet loss for minimizing handoff signaling rather than trying to guarantee zero packet loss. Cellular IP semi soft handoff exploits the notion that some mobile nodes can simultaneously receive packets from the new and old base stations during the hand off.

Cellular IP divides MN into Idle and Active states .It defines and idle mobile node as the one that has not received data packets for a system specific time *active state timeout* .In this respect, idle mobile nodes allow their respective soft-state routing cache mappings to timeout. These nodes transmit paging-update packet to notify new base station that mobile nodes new location at regular intervals defined by paging-update –time. When mobile node wants to send the data it changes the state to *Active.*

3.2 Multi-tier Architecture Supporting Mobile Multimedia Communications.

The proposed multi-tier wireless communication architecture based on Cellular IP supports the following capabilities.

a. Mobile Internet
b. Mobile Multimedia Communication
c. Seamless roaming.
d. Management of Mobile IP.
e. Multimedia Quality of Service.

In this proposed multi-tier architecture, the cellular hierarchy includes two level cells; they are the micro-cell and macro-cell. The policy is that Mobile IP is used in the macro tier and Cellular Ip is used in the micro tier. There is also an extra component called Resource Switching Management Center in micro –tier to improve capability of Cellular IP Network.RSMC is a control structure that combines gateway router and cache of BS, which can store MN's location information, forward data packets to MN and authenticate MN's identity. If a MN moves from on e Base s tation to another base station the mobile node sends a route update packet to the RSMC, then RSMC will update MN's location information after it gets this packet, and send s a message to notify HA and CN. Thus packets sent by CN will reach MN correctly via RSMC .An RSMC keeps track of its own micro cell and communicates with others thru Foreign Agent.

3.3 Soft-Handoff and Quality of Service

In this scenario soft handoff method is used to ensure Qos for Mobile Multimedia communication services. Multimedia data packets sent by the CN route correctly to the current location of the MN via RSMC.When data packets arrive at RSMC it will deliver to both the MN's old BS and new BS, such that we can reduce the probability of lost data packets. If MN moves over different RSM we can use the foreign agent to send packets to both new and old RSMC .By using soft handoff and multi-tier architecture the authors believe that mobile multimedia communication can be done successfully .

4.Comparison

The two strategies discussed in this paper for supporting mobility in multimedia communication, i.e network layer and application layer strategies have their own pros and cons .The advantage of using the network layer mobility as in the IP Based Multi-tier Network for Mobile Multimedia Communication Services are that it supports applications that are not mobility aware (e.g. TCP based applications) efficiently and reuses existing protocols for terminal mobility. However the Disadvantages of using this approach are that

i. The use of multiple protocols for terminal, service and personal mobility may increase terminal complexity.
ii. Network Layer Mobility management protocols (e.g. Mobile IP) relies in network elements for packet interception and forwarding to mobiles, as wells as sending necessary binding messages to the corresponding hosts.

The use of application level SIP protocol has its own advantages

a. It allows users to depend on their appliances rather than the network for supporting mobility on an end to end basis without reliance n and knowledge about abilities of network elements for packet interception and forwarding, i.e., mobile users can roam into SIP environments without concern about whether the support network layer mobility or not.
b. Allows dealing with mobility at a semantic level above IP terminals (e.g moving of a media stream from one terminal to another terminal called the service session handoff in self adaptive distributed proxy system as described above).

5. Conclusion

This paper discussed different strategies for dealing with mobility in Multimedia Communications followed by a comparison of the strategies. By passively monitoring and proactively adapting to the network variations using both application specific and application independent techniques as in [1] a pragmatic approach was given to provide good performance for the streaming multimedia applications.

Also SIP is emerging as a standard for signaling protocol for multimedia sessions in both wired and wireless network, the ease of deployment of Sip due to its text based nature also makes it a string contender for providing terminal service as well as personal mobility.

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