A Novel Content Provisioning Framework for Multi-technology Wireless Networks

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Abstract: This paper presents a novel framework for content provisioning in Multi-technology Wireless Networks while ensuring that QoS parameters are met as per application requirements. Our proposed QoS aware Transcoding Media Adaptive Gateway (QTMAG) intercepts all communication between the end-user devices and the content provider transparently and modifies the contents to be displayed on the target device according to its available resources and hardware capabilities. To ensure that the transcoded contents observe QoS requirements and administrative policies, an adaptive policy based network management system is implemented in conjunction with the transcoding and QoS monitoring system.
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1. Introduction

As the technology leaps forwards, the way information is delivered and presented on the end user mobile devices, depends solely on availability of their processing power, storage capacity, display resolution and communication resources.

As these resources vary with the variation of form factor of the end user devices, it calls for new techniques for content delivery and information presentation to these devices. Moreover, the applications that utilize these device-resources have to be flexible to downgrade their requirements in constrained scenarios. These applications have to make smart decisions by taking advantage of available resources if they are in abundance to improve the quality of presented contents.

The software applications are usually designed for specific operating system and hardware platform. Application portability between heterogeneous devices requires significant software development work. Moreover a common platform is required to port data contents and its UI specifications over a heterogeneous network without any dependencies on the underlying hardware and operating system.

In [1], author proposed a cloud based Service Oriented Architecture comprising of knowledge gathering and discovery system in conjunction with service oriented infrastructure for rich mobile user experience.

II. Background

The objectives of this research are to develop strategies for seamless content provisioning in resource constrained heterogeneous networked environments. The research aims to address the issues related to information transfer according to the available resources of end user devices such as mobile phones, handheld personal digital assistants (PDAs), laptops etc. which have limited processing and bandwidth capacities. This requires framework which transforms content into appropriate format for transmission over constrained networks and presentation of information on target end user devices using flexible mobile applications. Moreover, content provisioning to end users through ad hoc / peer-to-peer technologies is a promising target to achieve.

An important aspect of today's mobile applications is the availability of different types of wireless communication networks for end-user devices e.g. mobile phones are typically connected to the cellular networks for data and voice communications while higher level devices such as laptops, net-books etc. are connected to Wi Fi network. This poses a challenge for the researchers to adapt their applications to the variation in the performance of wireless access network as the user switches between various available network technologies.

Another major obstacle towards successful display of information/data on the mobile applications available on the end-user devices is in identifying capabilities of these devices including their display resolution, storage capacity, network bandwidth, available memory, battery life and computational limitations etc. For this purpose, we propose a framework that provides reliable communication features as well as advance techniques for presentation of delivered data through heterogeneous mobile networks and various end user mobile devices.

III. Proposed framework

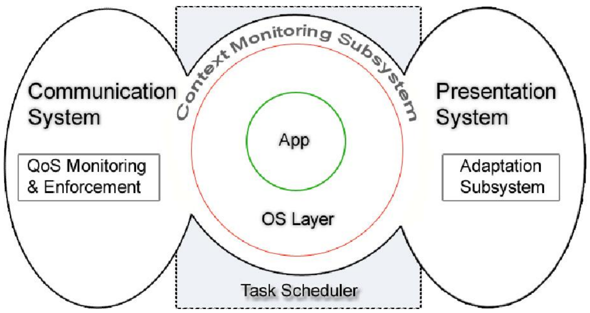

Fig. 1. System Model

Our proposed framework consists of two main systems as defined in the Fig. 1.

- Communication System
- Presentation System

A. Communication System

The Communication System consists of all the components that are associated with traffic flowing across the network and ensures QoS by following policies implemented dynamically according to the available network and other resources of communicating devices. The Communication infrastructure is an elaborate multi-technology network system as depicted in Fig. 3.

1) QoS Monitoring Subsystem

QoS Monitor integrated with Policy based Network Management System as proposed in [6] that is responsible for estimating network performance parameters for all flows across end-user devices. Each monitor is defined by describing the IP addresses and port numbers for the source and destination devices along with any specific transport protocol as mentioned in [7].

For QoS Monitoring, interfaces on each device are observed for inward and outward data transmission and records variation in delays and available bandwidth whenever it reaches a predefined specific threshold value. This gathered information is also fed to other attached modules that are responsible for ensuring minimum flow loss and reducing communication delays for end-user devices. For this purpose, the QoS Monitor acts as a client server application with its one component running as agent on the end-user devices and a central component on a central management server.

A typical Policy based network management system (PBNM) comprises of 4 main elements [8]:

1. NMS application typically running on centralized network management servers,
2. Policy Repository containing already defined policies to be used by the system administrators,
3. Decision Point for Policy triggering and (PDP)
4. Implementation Point for policy enforcement (PEP)

Decision Points for Policy triggering are deployed centrally in a core network that is responsible to decide what policies are to be implemented on each managed network node. The NMS application provides the user interface that allows the administrators to modify, save and install network policies centrally.

2) Enforcement Subsystem

The PEPs are responsible to provide directives for modifying the mobile applications network/services usage by deploying suitable policies from the policy repository. These directives are followed and policies are enforced on the end-user devices using the local PEPs on managed devices.

The network administrator determines the hardware (and PEPs) on which these saved policies will be installed.

B. Presentation System

The presentation system consists of Adaptation Subsystem that provides directives to modify Applications' presentation characteristics as well as select appropriate representation components on the target device according to the format of contents being provided through the adaptation subsystem. An HTTP transcoding proxy is placed inside the local intranet network that acts as the gateway for all end-user wireless networked devices.

On first request of any content from internet, the end-user device sends its device capability information using device notification packets (including CPU, available memory, network bandwidth, available storage, remaining battery etc.) to the HTTP Transcoding proxy where this information is stored temporarily till the time it is revoked by a more recent notification. Since most of the communication over the internet uses HTTP as the predominant protocol for data transfer, HTTP transcoding proxy forwards the client requests for multimedia contents to the internet resources/servers.

When the response is received from the internet servers, the HTTP transcoding proxy transparently converts these contents into appropriate format suitable to be represented over the end-user device according to its capabilities already notified to the proxy. The HTTP transcoding proxy is responsible for fetching from the internet resources and serving locally after converting these contents in format appropriate for end-user devices.

These contents are mostly text and images that are presented after transcoding on the end-user devices. In case of streaming media like video and audio feeds, the adaptive controller uses the device capability information already available with HTTP transcoding proxy for the requesting end-user device and converts the audio or video streams into suitable formats that are ready to be played at the end-user device.

The detail of all components of adaptation sub system is provided below elaborating each component and its role.

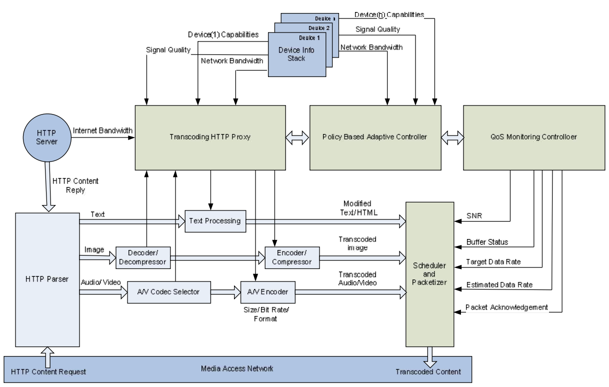

Fig. 2. Adaptive Transcoding Proxy Gateway Architecture

When the end user device requests contents from internet HTTP/Streaming/Application Server, their HTTP content request is intercepted by the adaptive transcoding proxy gateway that forwards this request towards the destination server on the internet. The internet server replies with HTTP content reply which is parsed by an HTTP Parser that separates the server response into text, images and audio/video streams.

The transcoding proxy takes into account end-user device Network Bandwidth, Wireless Connection Signal Quality and the end-user device capabilities to transcode the required contents. To proceed with transcoding process, the text from HTTP parser is processed to make it appropriate to be displayed on the target end-user device including replacement of HTML tags and text encoding schemes according to the display and language preferences of end-user device.

In case of images in the HTTP Content Reply from the internet server, these images are decoded/de-compressed and fed to the HTTP transcoder that encodes/compress them according to the suitable format to be displayed on the end-user device. When video/audio stream is received from the internet, the adaptive transcoding proxy gateway will select appropriate codec to parse the received multimedia stream and based on the requesting end-user device's capabilities, network bandwidth and channel characteristics using a policy based adaptive controller to encode the video/audio.

In this way the re-encoded video/audio or images or text are fed to the Packet Scheduler. The packet scheduler is responsible for ensuring Quality of Service (QoS) by taking into account the Signal to Noise Ratio (SNR) of wireless connection of target end-user device, its Buffer Status, estimated and actual target data rates of end-user device and acknowledgements of received packets.

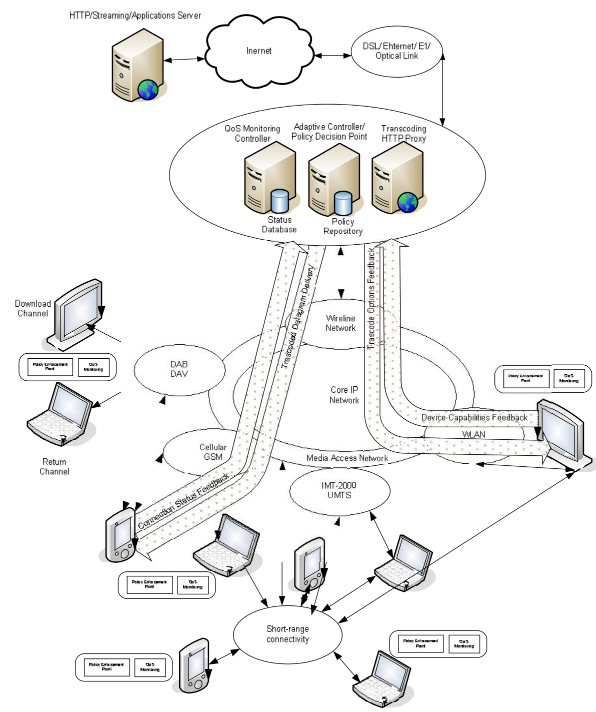

Fig. 3. QoS aware Transcoding Media Adaptive Gateway

The transcoding proxy also serves as an intermediate re-transmitting server for multimedia contents fetched from the internet to cache/buffer these contents locally to serve other subsequent requests of same contents by end-user devices. Moreover, it also hides the jitter in internet connection from the end-users by dynamically adjusting its buffer size to serve these requests. This also helps in maintaining QoS while avoiding disconnections when the end-user device switches from one type of access network to another during movement.

Another important feature of our proposed transcoding proxy gateway is that if a device switches from a high speed wireless access network to a low speed wireless access network that is not capable of playing back video streams, the proxy will use sequential animated images to replace video contents by using modified HTML pages in case of embedded video webpages.

Conversely, the video will be played back replacing the sequential animated images in case the end-user devices shifts back to a higher speed wireless network. In extreme case where the end user disconnects from the transcoding proxy gateway due to un-reliable wireless link or out of range network link, the transcoding gateway will keep on buffering the internet contents and pre-fetch other embedded resources in the requested page. This allows end users to play back these contents whenever they are re-connected to the access network without having to send request to the internet server again.

The Fig. 3 describes the overall communication architecture of our proposed system. The system backbone consists of a core IP network that is linked through high speed wire line connections to the access network infrastructure. These access networks connect various types of wireless devices through their respective media networks.

[9] proposed an architecture that transcodes media stream while ensuring quality of service but it only consider the device capabilities for Adaptation decisions.

In our architecture request from wireless connected end-user devices reaches the core IP network where the QoS aware Transcoding Media Adaptive Gateway (QTMAG) transparently registers and forwards this request to the destination server and waits for the reply on behalf of the requesting device. The reply from destination server is intercepted by the QTMAG using ARP proxy. This allows for near real-time media transcoding of the received contents on the fly before they are forwarded to the requesting end-user device.

[10] proposed a system where a receiver can understand and adapt the stream to fit the clients resource availability and QoS requirements. This is motivated by the following reasons: Adaptation and transcoding may be required to bridge the heterogeneity gap. It is important to minimize additional overhead for servers and clients. For scalability reasons, VoD servers should not be concerned about additional adaptation/ transcoding. Low power PDAs often do not have hardware support to decode the original stream. Therefore, on demand transcoding and adaptation of the quality should be performed on intermediate media.

In [2] author defines the system and the method may use a broadcast receiver accessory that may connect to a mobile device.

- The system and the method may have a bidirectional data connection between the broadcast receiver accessory and the mobile device.
- The broadcast receiver accessory may translate, reformat and/or repackage content into a form that may be viewed on the mobile device.
- The broadcast receiver accessory may have a tuner component, an application processor, an audio rendering element and/or memory.

In [3] author describes an architecture for providing services through Peer-to-Peer networks defining the service life cycle discussing the experimentation to verify the discovery and delivery of information. Author suggested future implementations in wireless networks.

In [4] author defines provisioning of service, quality of service provisioning in heterogeneous networks and multimedia content management by providing end to end QoS. System defines complete A/V (audio and video) service distribution with protected content generation and distributing it to all QoS enabled heterogeneous networks.

Author proposed framework providing service to client/end-user. Provision and offer of service are targeted in accessible manner providing QoS based signaling protocol suit for quality of service enabled networking infrastructure for resource allocations, monitoring and service subscription purposes.

[5] defines the fast growing advancement in technology in wireless communication and the use of mobile technologies availing the huge variety of services provided by high speed heterogeneous networks. Different QoS parameters can be specified to measure and ensure the quality of these services while author identifies two main and unique parameters used in mobile environment, seamless service guarantee and to ensure service degradation when client demands exceed the capacity of network. Author proposed network architecture and transport level services to satisfy the quality of service in regard of its parameters that make the mobility invisible to nodes of high speed fixed networks.

IV. Conclusion

This paper described our proposed framework for content provisioning to end-user wireless devices by considering their device capabilities, network constraints and QoS. The framework ensures that multimedia contents are delivered to the end-user device and converted into suitable format to be displayed and used in the applications deployed on these devices. The concept of introducing a QoS aware Transcoding Media Adaptive Gateway that transparently intercepts all the traffic flows between the end-user devices and the content provisioning servers ensures policy based enforcement of network management directives for smooth operation of all processes and applications.

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