3GPP TSG RAN WG2 **Tdoc RAN WG2 140/99**
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Source : **Nortel Networks**

Object : **Adaptative Radio Link Protocols**

1 Introduction

What is proposed in this document is a way to improve the quality of service associated with multimedia communications in a wireless environment. The Adaptive Radio Link Protocol concept falls into a general class of protocol enhancement techniques known as “protocol boosters” that are designed to provide improved end-to-end protocol performance without changing the semantics of the end-to-end protocol. Thus, while the effects of the Adaptive RLP protocol booster may be apparent to the communicating end points (e.g. improved throughput), the mechanisms and protocols used internally by the protocol booster are transparent to the end points.

2 Multimedia Communications in Wireless Environment

The Transmission Control Protocol (TCP) has evolved over many years of use in the wired local area and wide area network (LAN/WAN) arenas. Many of the algorithms used to optimise the performance of TCP in this environment are based on some underlying assumptions about the wired network where TCP is typically used; these assumptions include:

- the transmission medium is essentially error-free; bit errors rates are typically on the order of 10^{-9} or better.
- TCP packets are lost mainly due to congestion in the intervening routers.
- errors, and packet loss in general, tends to be random.
- errors, and packet loss in general, usually affect a single packet.
- the transmission channel has a constant bandwidth.
- the transmission channel is symmetrical – characteristics of the channel in one direction can be deduced by looking at the characteristics of the channel in the other direction.

In a wireless environment, however, most of these assumptions are no longer valid. The wireless channel is characterised by a high bit error rate with errors occurring in bursts that can affect a number of packets. Due to fading, the low transmission power available to the Mobile Station and the effects of interference, the radio link is not symmetrical and the bandwidth of the channel appears to fluctuate (rapidly) over time.

In the multimedia communications world, different applications have different requirements with respect to bandwidth, delay, assured delivery, etc. In the wired networks, because of the error-free environment, it is often easiest to use a common link control protocol and to solve congestion problems by “throwing cheap bandwidth at the problem” – i.e. remove queuing bottlenecks by using higher speed, more cost effective transmission channels. In a wireless environment, the amount of bandwidth available to the system is fixed and scarce; adding bandwidth on the radio link may be expensive or even impossible due to regulatory constraints. Therefore performance of a multimedia protocol must be enhanced by using mechanisms specifically designed to overcome the impairments found on a radio link that most affect the information flow of a given (class of) application.

For example, optimising bulk file transfer in a wired environment is simply a matter of allocating as much bandwidth as possible to the connection. In a wireless environment, part of the bandwidth is used in error correction – more error correction means less payload. However, more error correction increases the probability of correct delivery without retransmission; thus, end-to-end throughput may be increased by reducing bandwidth assigned to payload and using the freed bandwidth for error correction. TCP, as used for bulk file transfer, includes packets both for transporting payload to the receiver and for transporting acknowledgements to the sender. Both payload and acknowledgement packets are subject to errors and other impairments on the radio link. However, system throughput can be significantly reduced if acknowledgements are lost since this will cause retransmission of information that has, in fact, already been correctly received. Therefore, in this scenario, priority should be given to correctly delivering acknowledgements for information already received.

3 From 2G Systems

Link Protocols are a recognised mechanism used within the wired and wireless communications industries to mitigate the effects of impairments introduced by the physical transmission medium. A Radio Link Protocol (RLP) is one that is designed for the wireless environment to deal specifically with the types of impairments found on the radio link between a mobile station (MS) and the Radio Access Network (RAN). The detailed mechanisms employed by an RLP are usually specific to a particular air interface standard (AIS) and are tailored to the services supported by that AIS. An RLP may provide mechanisms to deal with:

- errors on the radio link. Error control schemes may include:
  - error detection only.
  - error detection and forward error correction.
  - error detection and retransmission.
- delay encountered in transmitting information over the radio link. Delay control schemes may include:
  - expedited delivery (“as fast as possible”).
  - bounded delay (“no longer than XX milliseconds”).
  - unbounded delay (“whenever you can”).
- delivery guarantees. Delivery control schemes may include:
  - assured delivery (i.e. recovers from all transmission and congestion losses).
  - best-effort delivery (i.e. recovers from most transmission errors).
  - relay service (i.e. no recovery).
- bandwidth conservation. Conservation schemes may include:
  - packet header compression.
  - generic payload compression.
  - application-specific compression

This list of RLP functions is by no means exhaustive and recent research has shown that performance can be significantly improved by using an RLP that is specifically tailored to the needs of a particular type of information flow or of a particular end-to-end transport protocol.

Current second generation (2G) wireless systems were designed mostly to handle voice traffic with some allowances for circuit-switched data; later, packet data services were grafted onto the 2G systems but these were uniformly treated as “best effort” packet services. The type of RLP used in 2G systems is typically based on the generic service(s) available to the MS; for example:

- *voice service* may use an RLP providing error detection and forward error correction.
- *packet data service* may use an RLP providing error detection and retransmission.
- *circuit switched data service* may use an RLP providing transparent bit service.

However, the introduction of multimedia communications in third generation (3G) wireless systems means that the traffic no longer has a set of homogeneous characteristics; as a result, many of the 2G wireless systems suffer from a number of design problems:

- *RLP tied to service category*. The RLP selected by the 2G system is based on the generic service used by the MS; the generic categories are usually voice, circuit-switched data, packet-switched data and, perhaps, signalling. This strategy assumes that all services within a category have the same basic type of service (ToS) requirements and that these requirements can be met by a single RLP. This strategy does not recognise different service requirements within a category; for example, different voice coding algorithms may have different delay and error tolerances, bulk file transfer over a packet data connection has different requirements from interactive video.
- *RLP chosen during setup*. The RLP is selected by the 2G system when the connection is initially established; this RLP is then used for as long as the connection exists. This strategy assumes that the nature of the service does not change over time. It does not recognise the case, particularly in packet-mode communications, where the subscriber may change from one mode (e.g. interactive browsing) to another (e.g. bulk file transfer). The only way to change the type of RLP is to terminate one connection and establish a new connection with different service characteristics. This obviously can lead to long delays and high processing demands due to connection setup overhead.
- *RLP operates independently*. The RLP is designed to be a stand-alone entity that tries to achieve a certain level of service based solely on the mechanisms employed by the RLP itself. However, many of the entities in upper layers of the protocol stack also employ performance enhancing mechanisms that the RLP is not aware of; in some cases, these mechanisms work against each other and produce an overall service level that is lower than would have been achieved if only one had been used.
- *RLP treats all information the same*. The RLP is designed to assume that the same service requirements apply to all information elements (e.g. packets) transported over a connection. In many protocol stacks, however, some information elements are more important than others. For example, in a packet-mode connection, control packets that regulate the flow of information may be deemed to be more important than the data packets themselves and should be accorded a higher priority, with greater assurance of correct delivery.
- *RLPs are a static set*. RLPs are typically defined during a standardisation process and no provision is made for adding a new type of information flow or type of service category, and its corresponding RLP, to that set. With the rapid introduction of new applications into wireless and packet data arenas, those applications may be forced to use an RLP that approximately, but does not quite, fit the application’s service requirements.

4 Proposal

What we propose is a mean for improving the quality of service for multimedia communications over a radio link by dynamically choosing the RLP that will be used to transport information without having to tear-down and re-create a connection. The operation of each RLP can be tailored to provide services that closely match the requirements of a specific end user or of an information flow or class of flow. RLP selection may be based on the end user’s profile, on the type of service selected, on the (changing) characteristics of the information flow, on the type of information element detected within the flow and/or on the current conditions of the radio link. This is accomplished through the following procedure:

1. The system includes a number of Radio Link Protocols (RLPs), each associated with a particular Type of Service (ToS). In the example of "Radio Link Protocol Example", these are the Gold, Silver and Bronze RLPs; any number of other RLPs may also exist. The Mobile Station (MS) and the Radio Access Network (RAN) each contain instances of these RLPs such that the Gold RLP in the RAN only communicates with the Gold RLP in the MS, Silver with Silver and Bronze with Bronze.

2. A connection – Connection 1 in the example – is initially created to transport information from the RAN to the MS.

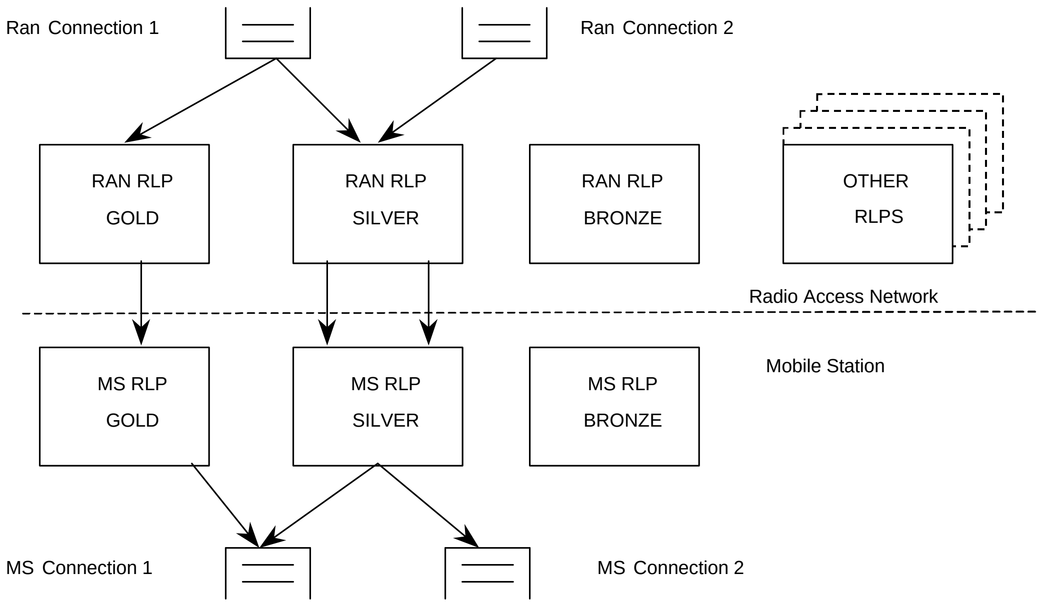
3. Based on information either included in the connection setup request or derived from the MS profile or negotiated between the MS and the RAN, an initial service requirement is determined and the corresponding RLP – the Silver RLP in the example – is identified. Other connections between the RAN and MS may also exist (Connection 2) and may also use the same (type of) RLP.

4. As the RAN exchanges information with the MS, the RAN monitors Connection 1 to determine if the service requirements of the connection are still being met by the Silver RLP.

5. If the RAN determines that the service requirements of an individual information element (e.g. a control packet) cannot be satisfied by the current RLP, the information element is directed to an RLP that can provided the appropriate ToS (e.g. to the Gold RLP); other information elements continue to flow through the Silver RLP. At the MS, all information elements are directed to Connection 1 regardless of the RLP used to deliver the element between the RAN and the MS.

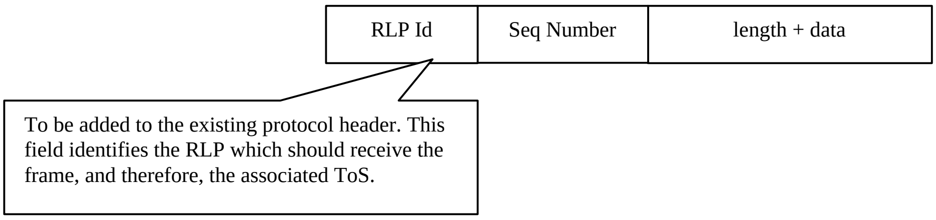
6. If the RAN determines that the service requirements of the entire connection cannot be satisfied by the current RLP, all future information elements travelling over Connection 1 are redirected to an RLP that can (e.g. the Gold RLP). Selection of a new RLP may be triggered by any one of a number of mechanisms, including:
   » an explicit request from the MS received either over a separate signalling connection or in-band over the same connection used to carry information elements.
   » analysis of the dynamic traffic characteristics exhibitted by the information flowing over the connection.
   » interpretation of (portions of) the information elements (e.g. control information contained in an information element header).
   » recognition of a particular information element carried over the connection (e.g. an "open file" request.)

7. For connections from the MS to the RAN, a similar process takes place but with the roles reversed – the MS monitors the connection and initiates changes in the RLP being used.



<u>RLP Protocol example</u>

The following figure provides an example of the handling of multiple RLP.



5 Conclusion

This document presents a mechanisms for dynamic Radio Link Protocol selection, which aims at improving end-to-end protocol performance in a multimedia wireless environment. As already explained, this RLP selection main be performed onto an on-going connection, without having to release the existing and re-create a new one.

This document has been presented for information. Meanwhile, if the principle is accepted, corresponding contributions will be issued on the RLC protocol.