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Abstract:

Cross-layer architectures diverge away from the existent network design approaches, where each layer of the protocol stack operates independently and the data between the successive layers is exchanged in a very strict and systematic manner. In case of cross-layering, information is allowed to be exchanged between adjacent and non-adjacent layers of the protocol-stack, by means of a broader and much more open data format. With cross-layer design the overall system performance can be improved by taking advantage of the available information across different layers. Having additional data to build decisions on and to parameterize and to adapt protocol behaviour can tremendously increase a protocol's performance. To achieve this, appropriate signalling methods and architectures are necessary. Standardization bodies have clearly started to work on support on all layers and are evolving to consider cross-layer-based approaches.

This report gives an overview of cross-layer design architectures and interaction techniques reported in the literature. Based on existing solutions a cross-layer interaction module (CLIM) adapted to satellite network is proposed. The main areas for cross-layer design in SATSIX are identified to be within QoS and Radio Resource Management and Mobility Management. Details of CLIM architecture adapted to these areas are described and examples on how to implement this model and other equivalent interaction models in SATSIX are shown.

Keyword list: Satellite, IPv6, Cross-layer, QoS, Resource Management, Mobility, Transport Protocol

Executive Summary

Cross-layer architectures diverge away from the existent network design approaches, where each layer of the protocol stack operates independently and the data between the successive layers is exchanged in a very strict and systematic manner. In case of cross-layering, information is allowed to be exchanged between adjacent and non-adjacent layers of the protocol-stack, by means of a broader and much more open data format. With cross-layer interaction the overall system performance can be improved by taking advantage of the available information across different layers. To achieve this, appropriate signalling methods and architectures are necessary. Standardization bodies have clearly started to work on support on all layers and are evolving to consider cross-layer-based approaches.

Cross-layer design offers great performance promises through the increased flow of information between layers and the additional control this information offers. However, in multiple-objective optimization, care must be taken to avoid undesirable (and unpredictable) interactions across parameters in the various layers. Cross-layer designs might cause problems since there will be trade-offs between the multiple optimization goals and the effect of the increased number of interactions in achieving those goals.

Differences between the architectures of proposed cross-layer designs are summarized below:

- Initially, many designs involved simply merging two related layers to accomplish a goal. A common set of merged layers are the PHY and MAC layers.
- Another design is to have uni- or bi-directional transfer of information between two adjacent or nonadjacent layers. This is done by creating new interfaces at the selected layers beyond those used between layers, called *direct communications.*
- Recently a third design has begun to use a different paradigm, by instead of building communications between specific layers, the architecture utilize a parallel structure that acts as a shared database of the system state, and being accessible to whichever layers who choose to utilize it, called *indirect communications.*

Based on the requirements and scenarios defined in WP2100 and WP2200, this report focuses on the specification and description of a cross-layer design adapted to the SATSIX network architecture. The report gives an overview of cross-layer design optimization architectures and techniques reported in the literature. This includes architectures for both direct and indirect cross-layer communications. The impact of cross-layer techniques on the layer relationships is also discussed, and so is middleware and cross-layer interaction support. A cross-layer interaction module (CLIM) adapted to satellite network is proposed and implementation details shown.

The main areas for cross-layer design in SATSIX are identified to have two main components:

- QoS and resource management
- Mobility management

In each component, the cross-layer interaction techniques that have been specified and used are described.

The QoS component of the proposed cross-layer architecture includes three techniques:

- The SIP and MAC cross-layer interactions are used to support the interworking between WiMAX and DVB-RCS, and multimedia QoS-aware application
- The transport and MAC cross-layer interaction (i.e. the interaction between TCP PEP and DAMA in the MAC) has been designed to optimise the way in which the available resource is used taking into account QoS mapping at the MAC layer and enabling data to be sent to the lower layers at the speed at which the MAC layer queues are emptied (flow-control).

- The interaction between IP and MAC scheduling are implemented in a way that can fully take advantage of QoS capabilities offered by the satellite systems.

The component for efficient mobility management includes:

- Network-layer mobility and interactions with link-layer
- Adaptive handover strategies and cross-layer techniques to achieve seamless user station mobility in a hybrid satellite wireless access environment
- Multimedia independent handover and multilayer communications
- Impact of network-layer mobility on transport protocols

The feature of middleware and the effect of cross-layer techniques on layer relationships is also discussed.