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Author Keywords: Ethernet; aggregation network; trains; prediction; signaling; location awareness

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Management of Aggregation Networks for Broadband Internet Access in Fast Moving Trains

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Abstract. Current satellite, GPRS and GSM systems lack from different shortcomings to provide broadband Internet access to fast moving trains. In this paper, we motivate that an Ethernet based aggregation network architecture is the best approach for realizing broadband Internet access in trains. The focus is on the management system for the Ethernet aggregation network and more specifically on the implementation of the management module for tunnel switching trigger management. The components of the management system are presented and three mechanisms for the implementation of the tunnel switching trigger management are detailed: a prediction based, a signaling based and a location aware approach. The different mechanisms are compared with respect to availability, complexity and network usage.

Keywords: Ethernet, Aggregation network, Trains, Prediction, Signaling, Location awareness.

1 Introduction

1.1 Motivation

Providing broadband Internet access to railway passengers is an interesting challenge. With the current emerging trials and early commercial releases it is only a matter of time before best-effort Internet on the train will become a reality. The satellite-based communication systems were the first solutions on the market but they lack uplink connectivity from train to satellite. These systems can combine satellite communication with GSM or GPRS receivers to ensure continuous up- and down-link coverage along the entire train trajectory [1]. Recently the first commercial bi-directional satellite communication system (4 Mbit/s down - 2 Mbit/s up) has been realized that can offer high speed Internet to high speed trains [2]. However as our own experiments on the Thalys trial Paris-Brussels

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show (see Table 1) the high satellite latencies make real-time communication impossible. This is due to the fact that the signal has to travel four times the distance Earth-satellite (twice for query and twice for answer). Currently an

Table 1. Main results from the Thalys Paris-Brussels experiment

Experiment	Result
Average experienced down-link bandwidth	ca. 1 Mbit/s
Average ICMP round-trip time	616 milliseconds
Average Voice over IP latency	4 seconds

alternative system architecture based on the WiMax pre-IEEE 802.16e standard is gaining interest: on-roof antennas with WiMax base-stations located near the railroad track provide a bi-directional broadband connection of 32 Mbit/s with seamless handoff in a high-speed environment [3]. In April 2005, the first broadband WiMax service on trains in the UK got operational [4]. Recently fast handoff between WiFi networks of roughly 5 milliseconds is established which promises near-seamless 802.11 roaming [5]. However, besides fast WiFi handoff the aggregation network which is responsible for the transport of data traffic from the fast moving users to the service providers' networks, has to be configured in-time and extended research is required on the management of the required tunnels in the aggregation network. The challenge is to design telecom networks in such a way that high bandwidth services which require a high level of Quality of Service – such as multimedia content delivery, video phoning and on-line gaming – can be provided. The focus in this paper is on the management of tunnel set-up and tear down triggers in an Ethernet aggregation network.

1.2 Ethernet Aggregation Network

The signaling protocols, used in this paper, are specifically implemented for Ethernet aggregation networks. This choice for Ethernet is motivated by the fact that telecom operators tend mainly for economical reasons towards networks consisting of standard QoS-aware Ethernet switches. Ethernet networks use a spanning tree protocol to maintain a loop free active topology. The legacy IEEE 802.1D [6] Spanning Tree Protocol (STP) and the IEEE 802.1w [7] Rapid Spanning Tree Protocol (RSTP), both use only N-1 links in a network of N nodes. This limits the amount of links that can be used in these networks but with the introduction of the IEEE 802.1s [8] Multiple Spanning Tree Protocol (MSTP) the bandwidth efficiency can be improved by maintaining multiple trees instead of a single tree. Most commercial switches are IEEE 802.1q & p compliant: i.e., they support the Virtual LAN (VLAN) technology and are QoS-aware (based on priority scheduling). VLANs provide a way of separating the physical topology in different logical networks and can be used to define end-to-end tunnels in the network. The configuration of VLANs can be performed automatically by means of the standardized GVRP (GARP VLAN Registration Protocol).

In summary, the ease of use and the auto-configuration of standard Ethernet, in combination with the recent advances in QoS support are probably Ethernet's strongest features.

The remainder of the paper is structured as follows: Section 2 presents the considered network architecture, whereas Section 3 details the implemented system for tunnel switching trigger management and elaborates on three trigger mechanisms. The management system design considerations are addressed in Section 4. Finally, the main conclusions are summed up in Section 5.

2 Considered Architecture

2.1 Aggregation Network

The FAMOUS (= FAst MOving USers) network architecture has already been published by the authors [9] and is depicted in figure 1. As can be seen in this figure, WiMax base-stations are positioned along the railroad track and every base-station is connected to an AGW (Access GateWay) which gives access to the aggregation network part. Note that in the aggregation network part traffic demands from separate users are not considered but groups of users are aggregated together per carriage. By aggregating the requests the system remains scalable for aggregation networks of realistic size. The traffic of each group of moving users is multiplexed in the AGWs into a VLAN tunnel. The aggregation network is responsible for the transport of the data traffic, by means of high bandwidth tunnels moving at high speed, to the service provider (SP) domain. The connection between the SPs and the aggregation network is realized by Service Gateways (SGWs).

2.2 Train Network - Aggregation Network Interaction

While commuters are moving along the railroad trajectory, their attachment point to the aggregation network will hop from one AGW to another. In order to preserve the connection between the train and the core network, tunnels must move with the trains. Due to the moving tunnel concept, seamless connectivity is not assured. However, service guarantees can be assured by making on-time resource reservations in the aggregation network. This prevents high congestion levels which are inherently harmful for the network performance during tunnel switching. There can be multiple connections per train, dependent on the number of antennas on the roof of the train. In this paper we assume that every carriage has its own antenna and that it is using a single associated tunnel in the aggregation network. These tunnels on which the data connections of fast moving users will be mapped, are VLAN-based tunnels which are responsible for the delivery to the correct AGW in the aggregation network. The VLANs are fixed end-to-end tunnels, automatically installed with GVRP. At their due time, tunnel reservations are registered for every connection, but only shortly before the connection will be effectively using the VLAN tunnel. When the train is no longer connected to the AGW and tunnel

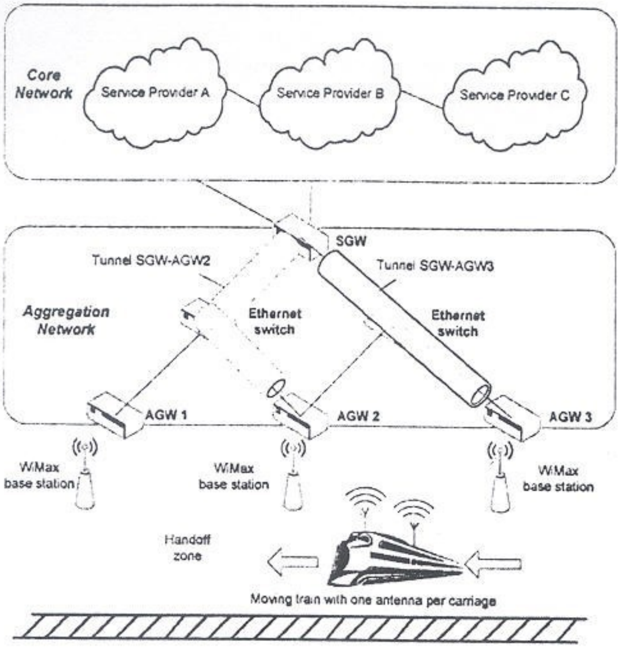


Fig. 1. Schematic representation of considered network architecture, which consists of a core part, an aggregation part and networks on the trains

reservations are no longer required, reservations are immediately released. In this way the system will always guarantee that the current and the next hop tunnel will be able to maintain the service level and that useless reservations are prevented. In a reservation-based system congestion levels and statistical multiplexing gains are manageable at the Connection Admission Control (CAC) level. In order to automatically activate the tunnels at their due time, a Layer 2 reservation protocol is developed, i.e. the GARP protocol G2RP (more details given in [9]). The designed protocols allow to make optimal use of VLANs (Virtual LANs) to support Multiple Spanning Trees in the Switched Ethernet networks. In this way network resources can be optimally used.

3 Management System

3.1 Overview

This paper focuses on the specific management framework for tunnel switching trigger, taking into account the exact positions of the trains. A diagram of a management system for aggregation networks to support fast mobile users has already been presented in [10]. Figure 2 shows the resulting management system. The off-line process has remained almost the same, but the online part is extended with new components. Two of them are essential: (i.) the triggers from trains and (ii.) the monitoring component. The first one collects information of trains (more specif-

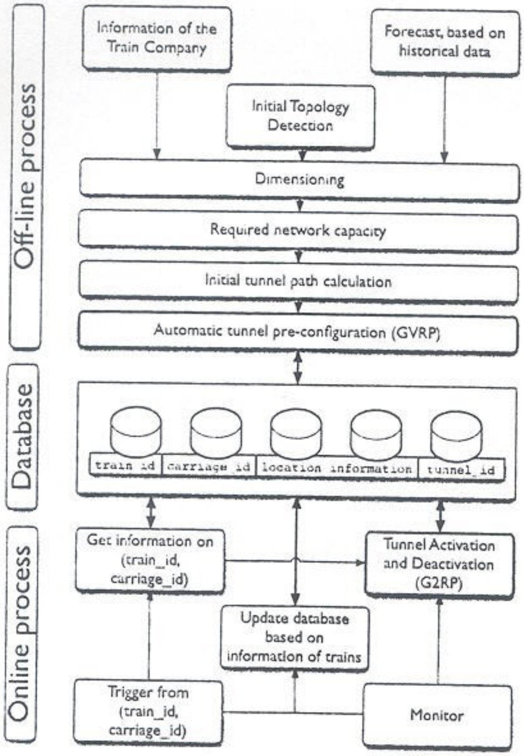


Fig. 2. Schematic overview of the management system. It consists of two parts: an off-line part and an online part. The off-line process is done before any trains are moving on the rail tracks. Its main purpose is the pre-configuration of the needed tunnels. The different components of the off-line part are published by the authors in [11]. The second process is the online one. The main purpose of this part is to activate the pre-configured tunnels at their due time and deactivate them when they are not needed anymore.

ically information of each carriage of trains) and sends them to the component that gets the relevant information from the tables based on the received triggers. Using this information, the decision is made if a new tunnel must be activated or if an existing one must be deactivated. The monitoring component collects information on the usage of the tunnels. Based on this information, the management system is completely sure the new tunnel is used before deactivating the previous one. The central component uses all the provided information to update the tables, hence the tables contain most recent information.

3.2 Tunnel Switching Trigger Mechanisms

The management system supports three different tunnel switching mechanisms: (i.) a prediction based, (ii.) one based on signaling and (iii.) an exact location aware approach. The following sections describe each of these mechanisms.

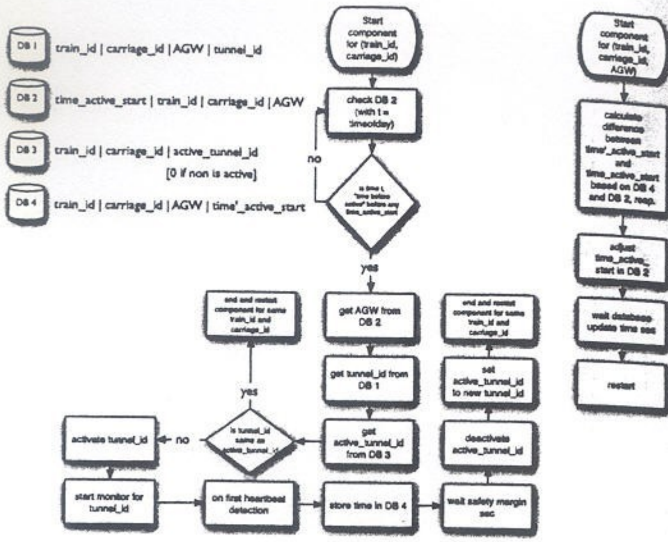


Fig. 3. Flowchart of the train position prediction mechanism. It uses tables based on information of the train company: the timetables and the velocity maps. Another process keeps the tables up-to-date based on the gained information.

Train Position Prediction - An overview of the mechanism is shown in figure 3. It is based on the exact timetables of the train company, together with a velocity map of the train speed on each part of the rail track system. Based on this information, a table is filled with time intervals and AGWs, together with `train_ids` and `carriage_ids`. The `train_ids` and `carriage_ids` are used to make a distinction between the different trains and their different carriages. A query on this table, at a certain moment in time, with a `train_id` and a `carriage_id` will result in a AGW, namely the AGW to which the carriage of that train is connected to, at that specific moment in time. Because trains can suffer from delays, the train position prediction mechanism has been extended with a heartbeat mechanism. Because the heartbeat signals, sent by a specific heartbeat component installed on every carriage, are sent directly to the management system, it allows for easy monitoring. Those signals are sent with a specific time between them, this is called the "heartbeat time" period. When a train is expected to reach a new base-station connected to an AGW, the system will check if the required tunnel has not been activated already. If this is not the case, the new tunnel is activated. Next the monitor detects the first heartbeat of the activated tunnel and uses this time to update the `time_active_start` of the table containing the expected arrival time of the carriage in the area of next AGWs. This is controlled by an external process, also shown in figure 3. After the monitor detected the first heartbeat through the recently activated tunnel, the previous active tunnel will be deactivated, after a pre-defined "safety margin" time period. This prevents the deactivation of a tunnel that is still in use.

Signaling - The second mechanism to keep track of the exact positions of the carriages, needs an action taken by the base-station. The moment the base-station detects an antenna of a carriage arriving in its covered area, it sends the `train_id` and `carriage_id` of the antenna to the AGW connected to the base-station. This AGW broadcasts a message including the `train_id` and the `carriage_id`. From the source Ethernet address the SGW knows the origin AGW of the message. From a lookup in its table, the correct `tunnel_id` is retrieved. Next the management system checks if the the found `tunnel_id` is activated already from another table (the one that holds the active `tunnel_id` for each `train_id`-`carriage_id` pair). If this is not the case, the `tunnel_id` is activated. After a specific time, the previously activated tunnel to that `carriage_id` is deactivated, after a pre-defined "safety margin" time. If no tunnel has been activated before for the considered `carriage_id`, deactivation is not needed. Finally the table containing the active `tunnel_id` for the considered carriage is updated with the new value. Because the speed of the train can be very high, and because the signaling process takes some time to activate the tunnel, it can be useful to handle a dedicated antenna to signal the presence of the train. This antenna is placed on the first carriage of each train. This antenna will not be used for the data traffic, but only for the signaling process.

Location Aware Approach - The third mechanism uses, just like the previous one, information obtained from the train. However, this information will be updated at regular moments in time. Therefor a specific "update time" must be set. The location aware components on the carriages send their information every "update time" seconds. For the location information, GPS modules are used, as they are more and more often installed on trains. With this information it is possible to know which carriage is in reach of which AGW, and so it is known what `tunnel_id` must be activated, from the appropriate table. As it is the case in the previously described signaling mechanism, the deactivation of the previous tunnel is done after a "safety margin", if there is any previous active tunnel.

4 Design Considerations

For each of the proposed mechanisms different constants must be defined, several variables must be declared and tables must be implemented. Table 2 gives an overview.

4.1 Message Sequence Charts (MSC)

- Train position prediction - In figure 4 the MSC is given for the train position prediction mechanism when a train is on schedule. It is shown that after activation of the new tunnel, the monitoring is started. After detection of the first heartbeat through the new tunnel, a safety margin is waited and the old tunnel is deactivated. As depicted, the new tunnel is ready when the first data is sent through the tunnel. Also the release of the old tunnel is done in a proper way.

Table 2. Summary of the design considerations

Type	Name	Prediction	Signaling	Location
Constant	safety margin	x	x	x
	time before active	x		
	heartbeat time	x		
	table update	x		
	location update			x
Variable	first activity	x		
Table	with `tunnel_ids`	x	x	x
	with `active_tunnel_id`	x	x	x
	with estimated `time_active_start`	x		
	with measured `time_active_start`	x		
	with GPS information			x

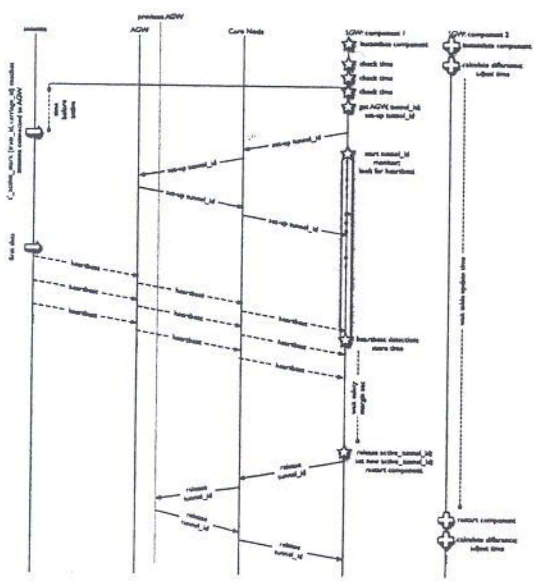
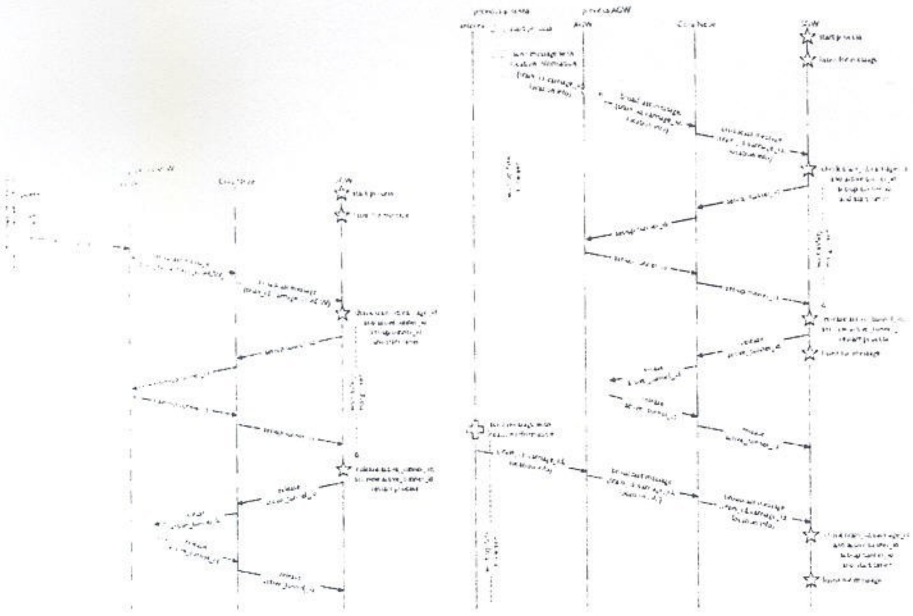


Fig. 4. The MSC shows both components that are instantiated at the SGW. Several parameters are indicated: the time before active, the safety margin and the table update time.

- Signaling - Figure 5(a) shows the MSC for the signaling mechanism. It shows the signal on which the tunnel activation is based. After receiving this signal, the system waits a predefined time, the "safety margin", and afterwards deactivates the old tunnel.
- Location aware approach - Finally, figure 5(b) shows the MSC for the location based train position detection. It is clear that, based on the knowledge of almost the exact position of the trains, all needed tunnels will be activated when they are needed. As disadvantages of this system, we mention



(a) MSC for signaling mechanism. (b) MSC for location based mechanism.

Fig. 5. MSC for different mechanisms

the purchase and installation of GPS infrastructure on trains and network usage by the broadcast messages with the GPS location information inside.

4.2 Comparison

For the comparison of the different approaches, we compare the three proposals on their availability, their complexity and their efficiency. These comparisons are given in tables 3 and 4. The first table compares the quality of the connection during tunnel switching in three cases: if the train is on schedule and during the detection of a small or a large delay. In the first table the influence of the used technology can not be neglected, as this determines the distance between the successive base-stations and this has consequences on the availability of the connection. If the system acts slowly, and the time between two handoffs is small, the system will fail. If the distance between base-stations is small, this failure will be dramatic, for bigger distances, the problem is not necessarily dramatic. This is why the WiFi technology is worse than the WiMAX technology with respect to the quality of connection. This quality also depends on the amount of delay but only for the prediction based method: for small delays, a small number unnecessary reservations will be made, for larger delays, this amount becomes bigger, leading to an even worse quality of connection. As a summary, following observations can be made: (i) if a management solution is desired,

Table 3. Comparison of different approaches concerning availability. When using the WiFi technology, the base-stations are placed very close to each other. The WiMAX technology permits larger distances between base-stations while keeping the overall bandwidth equal. We like to remark that for both cases (WiFi and WiMAX) all parameters are the same e.g., the location update time is equal.

	Prediction		Signaling		Location	
Train	WiFi	WiMAX	WiFi	WiMAX	WiFi	WiMAX
On time	++	++	−−	−	+	++
Little delay	−	+	−−	−	+	++
Large delay	−−	−	−−	−	+	++

Table 4. Comparison of three approaches concerning complexity and network usage. The complexity is measured in terms of the number of required tables, variables and constants, together with the required number of component instantiations. The network usage is determined by the number of messages for tunnel set-up and tear down.

Metric	Prediction	Signaling	Location
Complexity	−	++	+
Network usage	++	+	−

which is transparent to the existing base-stations and managements components on trains, the prediction approach is the only possible solution; (ii.) although, if the complexity of this prediction approach is unaffordable, a signaling or location aware solution is preferred; (iii.) a location aware approach has the advantage that tunnels are always established in time at the expense of the more complex GPS management components.

5 Conclusion

As a reaction on the existing technologies, which suffer from different kinds of problems to provide broadband Internet access to railway passengers, we proposed a new approach, based on an Ethernet aggregation network architecture. This paper focused on the management system for the tunnel switching trigger generation. Several mechanisms for the management and generation of the necessary triggers have been elaborated on. The weaknesses and strong points of the different mechanisms have been addressed. The involved software components and database structure have been detailed, together with a motivation for the implementation choices.

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References

1. Icomera wireless onboard internet, web site. *http://www.icomera.com.*
2. Broadband internet access on train, web site. *http://www.21net.com.*
3. Wi-lan launches libra mobilis, press communication. *http://www.wi-lan.com/news/press/20041019.htm.*
4. P. Judge. 100 mph wimax hits the rails to brighton. *http://www.techworld.com/mobility/features/index.cfm?FeatureID=1351*, April 2005.
5. Ramani I. and Savage S. Syncscan: Practical fast handoff for 802.11 infrastructure networks. *Proceedings of the IEEE Infocom Conference 2005*, March 2005.
6. IEEE 802.1D. Standards for local and metropolitan area networks: Media access control (mac) bridges. 1990.
7. IEEE 802.1q. Standards for local and metropolitan area networks: Virtual bridged local area networks. 1998.
8. IEEE 802.1s. Standards for local and metropolitan area networks: Multiple spanning trees. 2002.
9. F. De Greve, Van Quickenborne F., and et al. Famous: A network architecture for delivering multimedia services to fast moving users. *To appear in Special Issue of the Wireless Personal Communications Journal, Springer Publishers*, 2005.
10. Frederic Van Quickenborne, Filip De Greve, Filip De Turck, and Piet Demeester. On the management of aggregation networks with rapidly moving traffic demands. *IFIP/IEEE International Symposium on Integrated Network Management*, 2005.
11. Frederic Van Quickenborne, Filip De Greve, Filip De Turck, Ingrid Moerman, Bart Dhoedt, and Piet Demeester. Optimization models for designing aggregation networks to support fast moving users. In Gabriele Kotsis and Otto Spaniol, editors, *EuroNGI Workshop*, volume 3427 of *Lecture Notes in Computer Science*, pages 66–81. Springer, 2004.

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