The SANDRA Communications Concept - Future Aeronautical Communications by Seamless Networking

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Abstract. The EU SANDRA (Seamless Aeronautical Networking through integration of Data-Links, Radios and Antennas) project [1] aims to design, specify and develop an integrated aircraft communication system to improve efficiency and cost-effectiveness by ensuring a high degree of flexibility, scalability, modularity and reconfigurability. SANDRA aims at the definition of an access to an open system resulting in a collection of communications technologies targeted at specific operational settings. Within the paper the main ideas of this envisaged communications concept are addressed. Furthermore, quality of service management strategies are assessed with respect to their applicability and efficiency in the ATM (Air Traffic Management) context. Additionally, techniques for the selection of links for data transmission and the interaction between technology independent and technology dependent components in the networking architecture are covered by means of standardized communication protocols such as IEEE 802.21 and ETSI BSM extensions.

Keywords: Seamless networking, IPv6, QoS, aeronautical communications.

1 Introduction

The vision of ACARE (Advisory Council for Aeronautics Research in Europe) for 2020 [2] shows that Europe has to create a seamless system of air traffic management that copes with up to three times more aircraft movements than today by using airspace and airports intensively and safely. The development of sophisticated ground and satellite-based communication, navigation and surveillance systems will make this possible. Furthermore, goal is to reduce significantly the noise nuisance, and therefore, large airports can operate around the clock. Finally, this will ensure flying safely in all weathers and aircraft are running on schedule 99% of the time.

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There is a need for this new approach in order to achieve a broader level of integration for the required increase of capacity, safety, security, and efficiency of air transportation operations which keeps at the same time the complexity and cost of on-board networks and equipments within a sustainable level. For these goals the SANDRA integrated network concept with IPv6 as final unification point (target 2025 and beyond) has to be developed. Recently, ICAO (International Civil Aviation Organization) adopted IPv6 for use within its future IP-based aeronautical telecommunications network (ATN) [3].

In the following the approach towards seamless networking integration is described. Details are given in the structure of the SANDRA communications concept and its working structure. Furthermore, quality of service management strategies are assessed with respect to their applicability and efficiency in the ATM context. In particular addressing the service demands of ATM communication, such as strict latency and loss limitations are considered herein. This also covers techniques for the selection of links for data transmission and the interaction between technology independent and technology dependent components in the networking architecture by means of standardized communication protocols such as IEEE 802.21 and ETSI BSM extensions.

2 The SANDRA Programme for Seamless Networking

The vision of SANDRA [4] is the integration of aeronautical communications systems using well-proved industry standards to enable a cost-efficient global provision of distributed services. SANDRA system is considered as a ‘system of systems’ addressing five levels of integration: Service integration of a full range of applications and services (ATS, AOC, AAC, APC); Network integration of different radio access technologies through a common IP-based aeronautical network and interoperability of network technologies (ACARS, ATN/OSI, ATN/IPS); Radio integration of radio technologies in an Integrated Modular Radio (IMR) platform [5], [6]; Antenna integration of an asymmetric high data rate downlink by development of an hybrid Ku/L band SatCom antenna; WiMAX adaption for integrated multi-domain airport connectivity. i.e., AeroMACS.

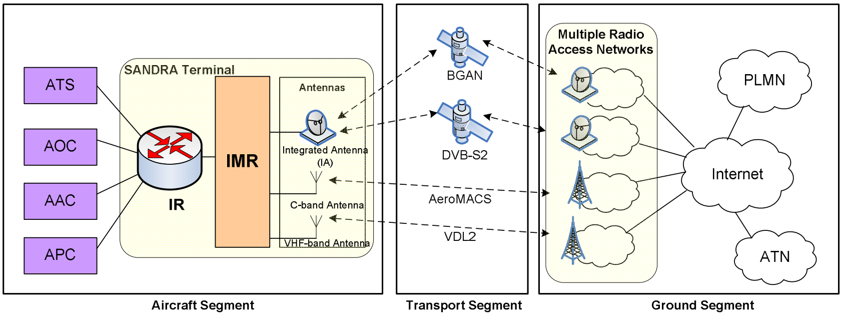

Fig. 1. SANDRA Network Architecture [6]

Considering the communications network, SANDRA spans across three segments, i.e., aircraft segment, transport segment (resp. wireless access segment) and the ground segment, as shown in Fig. 1. The aircraft segment contains the main functional components: the integrated router (IR), the integrated modular radio (IMR) and the antennas consisting of a hybrid Ku/L band integrated antenna (IA), a VHF band antenna and a C-band antenna..

The integration of different service domains with very heterogeneous requirements through a cost-effective and flexible avionic architecture is thus one of the main challenges addressed by SANDRA. Under this perspective, the SANDRA communications system presents a key to enable the global provision of distributed services for common decision making based on the System Wide Information Management (SWIM) concept [7], and to meet the high market demand for broadband passenger and enhanced cabin communications services.

2.1 Aeronautical Seamless Networking Environment of SANDRA

The following sections and Fig. 2 give an overview of the main tasks if the seamless networking aspects in the SANDRA project, namely: interworking of different data link technologies (ground-based, satellite-based, airport systems as main streamline for validation, and air-to-air MANET as long term extension), interoperability of network and transport technologies (ACARS, ATN/OSI, IPv4, IPv6 networks), and integration of operational domains (ATS, AOC, AAC, APC).

Additionally, a large effort is spent in the validation and testing of the SANDRA integrated airborne network design [8]. Capacity limits and overall system performance on future air traffic scenarios, services, and applications are assessed. This gives input to the development of a prototype implementation and its testing. In 2013, the overall SANDRA concept will be validated and demonstrated within a test bed and during flight trials. The planned lab environment is illustrated in Fig. 2.

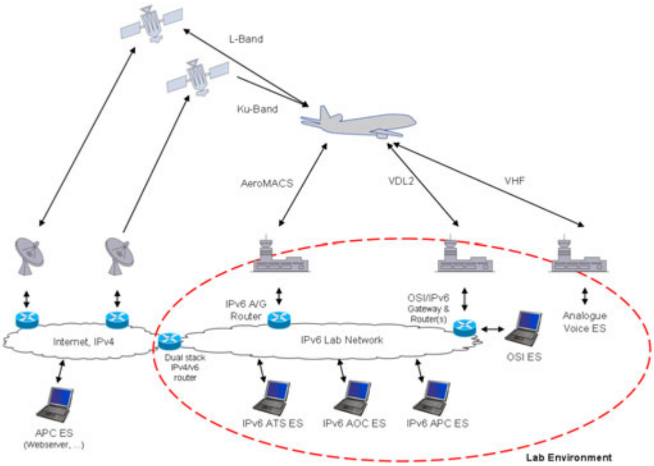

Fig. 2. Aeronautical seamless networking environment of SANDRA

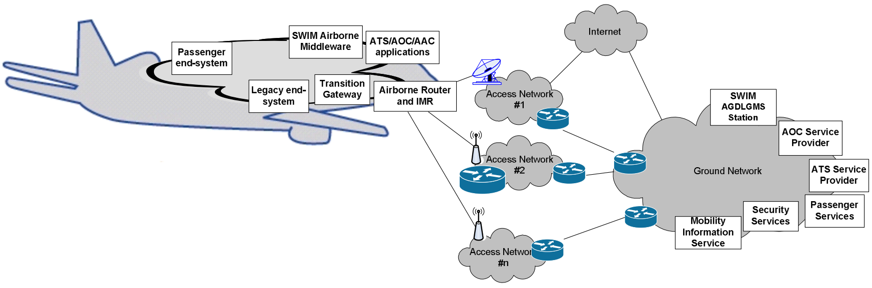

Fig. 3. High Level overview of the SANDRA system from a functional point of view [9]

2.2 Network Architecture and Interoperability

Topology Level: The aim of the SANDRA network architecture is to allow for onboard end systems to communicate with other end systems located on the ground through potentially more than one radio link at a given time (e.g. combining higher throughput satellite with lower latency AeroMACS). From a topology point of view, the functional architecture can be illustrated as shown on Fig. 3.

On the airborne side of the network, several functional entities are represented, like the passenger end systems which will mainly use the SANDRA network architecture in order to access the Internet and specific ATS/AOC applications which will communicate with ATS/AOC service providers on ground through the use of multiple access networks technologies (e.g., AeroMACS, satellite communications, etc.). On the ground side of the network, the counterparts to several of the airborne side functional entities are presented. In order to provide efficient service, the SANDRA network architecture relies on various functionalities provided on the ground like the Mobility Information Services and the Security Services. The SANDRA system supports the SWIM architecture and the related airborne and ground components of the SWIM architecture are also shown in Fig: 3. The SWIM based ATS/AOC applications will interface with the SWIM airborne middleware on the airborne side and the SWIM Air-Ground Datalink Ground Management System (AGDLGMS) stations on the ground. In order to support multiple data links with variable characteristics and constraints (e.g. local coverage of AeroMACS vs. global coverage of the satellite, variable data rate and latency), the onboard network and the various access networks are interconnected by the airborne router and the IMR. It is at this level that all the functionalities related to Quality of Service, Resource Management, Packet Scheduling and Link Selection take place. Furthermore, mobility and security functions are also strongly linked to the Packet Processing that takes place in the airborne router and IMR. Finally, in order to provide interoperability with legacy end systems which might be using protocols not natively supported by the SANDRA system, the airborne architecture includes a transition gateway. This gateway implements transition mechanisms required in order to adapt legacy protocols to the SANDRA network architecture (these include but might not be limited to tunnelling, protocol translation, higher layer proxying, etc.) [9].

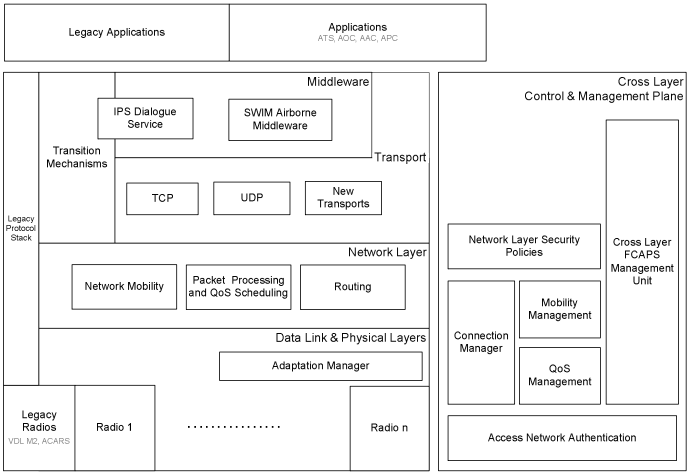

Fig. 4. High level overview of the Airborne Functional Architecture

Airborne Level: The main focus of the SANDRA project is on the airborne aspects of the functional architecture. However, some of the functions to be supported by the system may require the presence of a ground located counterpart. In this case, the study of these ground elements will be performed for completeness purposes.

Fig. 4 presents a high level overview of the functional architecture focusing on the airborne level. In order to simplify the description, the presentation is made following a layered architecture (similar to the OSI model) to which several cross-layer extensions are provided following the principles described in [10].

A clear separation between the user (data) and control planes has been performed as presented on Fig. 4. The user (data) plane includes all the functional blocks that are directly related with the transport of data while the control plane assures the control of this transport as well as the management of the SANDRA system. At the topmost layer of the architecture, the Applications, both legacy and non-legacy applications are to be supported by the SANDRA system. For legacy applications, three possibilities exist:

1. These applications can use the legacy protocol stack and legacy radio, which corresponds to them operating as they would without the SANDRA system.
2. These applications can use transition mechanisms in order for the traffic they generate to be transported using the SANDRA system
3. Or, these applications can be adapted in order for them to directly interface with a middleware such as the dialogue service or SWIM through the use of a SWIM adapter.

Non-legacy applications are considered to be using one of the supported middleware layers or to directly use any of the transport layer protocols supported by the architecture. At the network layer, several functionalities such as packet processing and QoS scheduling are implemented in addition to functionalities related to network mobility and security. The network layer can either directly make use of radios if these radios implement the correct interface or it can be connected to the IMR.

The IMR implements the data links and physical layers of the protocol stack and also provides an abstraction layer between the radios and the network layer packet processing. The Adaptation Manager block in the user plane at the Data Link and Physical layers acts as this abstraction layer. The Adaptation Manager is responsible for interfacing the multiple radios to the network layer in a common and standard way even if these radios do not provide similar interfaces to be connected to the network layer.

In parallel to the data plane (in which user data is processed), the functional network architecture presented on Fig. 4 includes a cross-layer control and management plane. The SANDRA system requires a close integration of the network, data link and physical layers in order to support complex networking scenarios such as seamless mobility, handover, QoS management and security. In order to perform this, several functional entities coordinating the interactions between the functions implemented at the various layers of the stack have been identified. These functionalities range from the overall management of the SANDRA system elements (based on the FCAPS model [11],[12]) to the control and management of connection in terms of QoS and Link Selection. Additionally, security and mobility related functional entities are also present. [9].

2.3 Network Design

Since IPv6 is the unification point in the SANDRA network, there is the need of the design and adaptation to an aeronautical internet. Main focus within this task is the handling of the network management and also of the resource management. Additionally, effort is spent for the development of new and efficient handover and mobility management algorithms and concepts, respectively. Also an IPv6 based naming and addressing architecture will be provided. Due to the high degree of mobility on a global scale and the heterogeneous network environment (i.e. short-range and long-range terrestrial as well as satellite access technologies), work on a network mobility (NEMO) based IPv6 protocol started in contrast to the ICAO chosen Mobile IPv6 protocol supporting only host mobility.

3 Quality of Service Management and Interoperability

3.1 QoS Definition for Aeronautical Networks

The term Quality of Service (QoS) is used in a variety of different ways and often depends also on the context that it is used in. One notion of QoS denotes the performance of a service from the users view. A measure for the grade of QoS is how good the performance attributes of a service match with the demands made on it. The kind of attributes which are relevant and need to be fulfilled depend thus naturally on the context of the service. While for many other services perceived or qualitative QoS measures are applicable, the ATM communication environment envisaged here makes high and precise demands on different attributes, presented later on in detail. [14] provides a good overview and summary of different aspects of QoS provision in the context of heterogeneous networks, such as present in the ATM environment considered in SANDRA.

The provision of QoS in an operational and safety critical aeronautical environment is however considerably different from the applications and demands in the Internet. Service parameters such as defined in [13] thus cannot be directly applied here. The most intuitive reason for this is that a violation of QoS attributes in Internet applications results in a reduced service quality, which is naturally undesirable and bothersome for users, but has not necessarily implications on operational events and safety of life. In the aeronautical domain, for the management of air traffic this is decisively different. Late arrival of e.g. directive commands issued by the controller for the pilot can have catastrophic effects. Also corrupted messages or multiple receptions of messages can have such serious consequences, affecting the safety of the airplane and the passengers. For this reason it is not sufficient if the QoS mechanisms for ATM communication try to achieve the requirements as far as possible but it is necessary that the requirements are definitely met. In a joint study of Eurocontrol and the Federal Aviation Administration (FAA), potential future communication technologies which are suitable to provide the necessary safety and regularity of flight have been investigated and requirements for the future application services have been derived. The results of this study have been published in the so called “Communications Operating Concept and Requirements for the Future Radio System (COCR)” [15]. Within this study the concepts of ATM have been analyzed from an operational perspective and the expected technical requirements have been formulated, also for services which are not yet deployed but are expected to be deployed in the future. The results in the COCR provide information for all operational services with respect to their periodicity, volume and technical requirements. The main QoS requirements for the services can be categorized into transmission delay, expiration time and continuity. The transmission delay (denoted $TD_{95,FRS}$) hereby sets the maximum transmission latency until successful reception at the receiver within which 95% of all messages must have arrived. For messages which are not fulfilling this requirement, e.g. due to a packet loss requiring retransmission or buffering delays, the fraction of messages specified by the continuity requirement must have arrived within the expiration time. The COCR specifies the QoS requirements per service, but also for aggregated Classes of Service (CoS).

Within the SANDRA QoS activity, the problem is addressed how different communication links can be integrated into a seamless network and which mechanisms and approaches are suitable to allow provision of the required QoS. SANDRA hereby focuses on the network layer QoS mechanisms mainly. Fig. 5 illustrates the general approach. One requirement for the layer 3 QoS mechanisms is that they must be interoperable and independent of the type of used link. Going beyond this, also the uniform interfaces (denoted Service Access Points, SAP in the following) to the technology dependent L2 are in the scope of SANDRA and discussed hereafter in more detail.

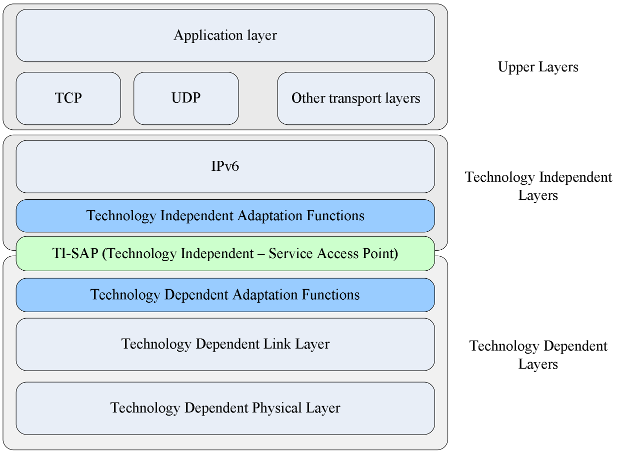

Fig. 5. Functional interaction between technology independent higher layers and technology dependent lower layers

3.2 QoS Mapping in the SANDRA Architecture

As straightforward from the considerations drawn in the previous section, the necessity for the SANDRA architecture is to simultaneously manage different QoS traffic profiles and transmission technologies over which different services have to be handled, translate into a QoS mapping problem. Beside the technical challenges that arise in selecting the L2 queues to which the traffic has to be forwarded depending on the QoS requirements (scheduling and QoS mapping problem), a particular attention has to be reserved to the characteristics of the QoS architecture, being embedded in the SANDRA's. Apart from the specific QoS model being adopted (IntServ or DiffServ as sketched in the following sections), some attention has to be addressed to how L3 and L2 intercommunicate, by preserving the QoS requirements specified in the SLSes of the specific traffic service. In this respect, different approaches can be applied. Ad-hoc solutions can be deployed, by extending for instance the functionalities and the related primitives already available from the ISO/OSI protocol stack. Given the scope of the SANDRA framework, it is instead better to have a model in line with architectures currently or going to be standardised. In this perspective, the features offered by the ETSI BSM protocol architecture are worth being considered. The main peculiarity consists in the definition of the SI-SAP interface, virtually separating the upper layer (Satellite Independent, SI) from the lower layers (Satellite Dependent, SD) and providing dedicated primitives to efficiently manage QoS, Address Resolution and Multicast functionalities over satellite.

The overall ETSI BSM protocol architecture is depicted in the following picture, where the main components are:

- SI layer: it implements the upper layer and in particular the IP protocol (versions 4 or 6). It also incorporates the Satellite Independent Adaptation Function (SIAF) module, which is responsible for adapting the SI functions to the characteristics of the lower layer specification, through dedicated primitives.

- SD layer: it implements the lower layer, in particular the datalink and the physical ones. It also implements the Satellite Dependent Adaptation Functions (SDAF) module, which interacts with the aforementioned SIAF through dedicated primitives.
- SI-SAP interface: it logically separates the SI from the SD layers, providing a set of dedicated primitives, exchanged between the SIAF and SDAF modules, responsible for QoS, address resolution and multicast functionalities.

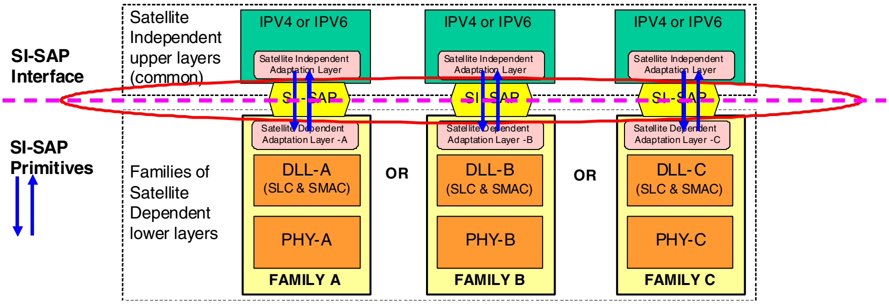

Fig. 6. ETSI BSM protocol architecture and SI-SAP interface definition

In this light, it is reasonable to extend the principles of the ETSI BSM protocol architecture for application in the SANDRA framework, to particularly address the QoS requirements of aeronautical networks.

In fact, two main “ingredients” of the SI-SAP interface can be re-used and properly extended to match the requirements of the SANDRA functional architecture: the Queue Identifier (QID) and the QoS primitives. The former is defined in the ETSI BSM protocol architecture as identifier of the L2 physical queues, so to allow an efficient QoS mapping between L3 and L2 queues, through the dedicated QoS primitives. The latter, in turn, allows actually implementing the QoS mapping algorithms and offering the essential tool to perform the resource allocation, based on the requests coming from the upper layers. The QoS problem in the SANDRA network involves not only resource allocation issues but also transmission technology selection, thus requiring the extension of the current SI-SAP interface functionalities along with the use of the IEEE 802.21 architecture in terms of the Media Independent Handover (MIH) functions. In practice, the QID has to be conceptually extended in a way that it incorporate both queue and link identifiers. Besides, the integration and the interaction of the ETSI BSM and the IEEE 802.21 architecture is of primary importance to perform the communication of the link selection to the upper layer and perform the resource allocation based on the requirements notified from the higher layers (e.g., application protocol or management plane). To this end, the SI-C-QUEUE primitives will be conveniently extended in their scope so to also include the new functionalities, thus allowing the different components to interwork properly according to the SANDRA network characteristics.

At this point, the final point to be addressed is the way the described protocol architecture integration (ETSI BSM and IEEE 802.21 namely) can be finally embedded in the real architecture of the SANDRA network. In this respect, a particular attention has to be reserved to the IR and IMR interaction. Although the SI-SAP interface has been conceived to logically separate the upper from the lower layers within a satellite terminal, it can be easily extended to physically separate two different components, by distributing the implementation of the primitives. This can be done by re-thinking the SI-SAP interface as the separating IR and IMR; these, in turn, will implement the related QoS primitives, thus working as the SIAF and SDAF modules in the original ETSI BSM architecture.

The overall system function can be then summarised in the following operations:

- In case the QoS requirements are constrained to a specific link by the upper layer, the IR will signal the selected transmission technology along with QoS request in a dedicated QID to the IMR, which in turn will forward the forthcoming data traffic to the specified transmission link. The availability of the transmission link is known after the start-up phase, which is accomplished by suitably combining the SI-C-QUEUE-open primitives with the MIH functionalities.
- In case no link-constrained request is performed by the upper layer, the IR simply signals the IMR about the QoS requests. In turn, the IMR will be responsible for running the link selection algorithm to identify the transmission technology most appropriate to match the received QoS requests. Also in this case the signalling is performed through real exchange of the SI-SAP primitives; in particular, in this case the QID will basically contain an identifier for the QoS request and a default value of the transmission technology, being it not explicitly selected by the upper layers.
- In case a link was no longer available or its availability was reduced (upon notification through the specific MIH functions), the IMR would in turn notify it to the IR through the corresponding enhanced SI-C-QUEUE primitives to trigger a new resource allocation. The IR in turn will run a new resource allocation request to match the new link configuration, by modifying or demanding the assignment of a new QID.

The overall interaction between the SANDRA components is represented in the following Fig. 7.

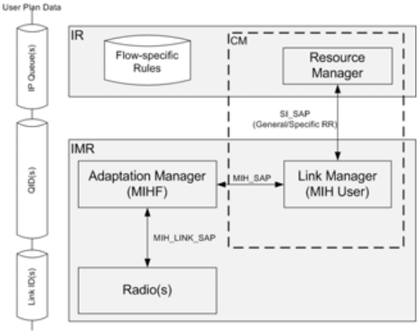

Fig. 7. Interaction between IR and IMR modules within the SANDRA network

3.3 QoS Management Architecture

In contrast to QoS architectures which are deployed in the internet, the QoS design here has to comply with a range of security and safety requirements which limit the freedom of choice for a QoS architecture considerably. The selected QoS management architecture should also rely on well established and standardized solutions. From today's perspective, one of the major design constraints is the strict separation of operational (ATS and AOC) and non-operational (AAC and APC) services within the network due to safety. While this separation is a real requirement nowadays, in SANDRA an all-integrated, seamless network is envisaged for the far future, which integrates also operational and non-operational services and provides the required safety at the same time. Naturally this has also an impact on the QoS architecture. One major impact of this different design is on the Connection Admission Control (CAC) and Congestion Control (CC) functionalities. In a purely operational network for instance, neither a rejection of a communication request of a pilot is acceptable, nor is delaying the transmission of the message to a later point in time to avoid congestion, if this would mean violating the maximum latency of the message. Overload situations which lead to such events such has to be prevented by proper network dimensioning and CAC/CC mechanisms are not strictly applicable. When integrating operational (op) and non-operational (non-op) services the situation changes however. Here it must be ensured that the op services always get the resources and priority they need and may not be affected by the non-op services, such as passenger communication. For the QoS architecture it is thus necessary to deploy methods for prioritization of the op-services and to have mechanisms ready which allow flow shaping, CC and CAC for the non-op services. The detailed functional QoS management and the interaction of the scheduling, CC and CAC functionalities is going beyond the scope of this paper, so the focus here is put on the suitability analysis of different QoS architectures, namely DiffServ and IntServ in an aeronautical operational environment.

3.3.1 IntServ QoS Approach

The IntServ architecture [16], [17] was developed for supporting specific QoS for end-to-end sessions across networks. In this approach, single flows (representing a stream of packets) are identified and treated individually. Every packet is checked for the resources it is entitled to receive. For this purpose the state of all flows in the network has to be periodically signalled among the routers in the end-to-end path of each flow. The Resource ReSerVation Protocol (RSVP) [17] was designed for this purpose. IntServ also has connection admission control mechanisms as an integral part of its functionality which admits new traffic to the network only if sufficient resources are available. By doing all this IntServ can guarantee hard upper bounds for packet delays and packet loss caused by buffer overflow. Moreover IntServ can rely with RSVP on an existing and well deployed signalling protocol. The per-flow treatment also allows Multi-Level-Priority-Preemption (MLPP) which can be beneficial to differentiate ATM messages according to their priority and urgency.While these IntServ features match very well with the QoS requirements in the ATM environment, the application of IntServ would have several major drawbacks. As is the case for all IntServ architectures, the main drawback is the scalability of the system and the signalling overhead. The traffic profile of ATM message exchange as predicted in the COCR consists of mainly small messages in the order few bytes, reaching at maximum several kilobytes in single cases. In the downlink for instance (i.e. aircraft to ground in ATM terminology) the maximum message size is 2763 bytes for the FLIPINT service. Estimations on the traffic profile have shown that the maximum message arrival rate hereby is slightly below 1 msg/s per aircraft at maximum, having an average of less than 0.1 msg/s per aircraft. This means in practice that either for every message a dedicated IntServ flow would have to be initiated and signalled, or an IntServ flow needs to be setup and kept alive for a longer time without being used most of the time, and accepting the overhead caused by the periodic keepalive messages necessary for this. Besides the volume overhead of the IntServ signalling also the time required for session initiation is an important overhead, considering that some messages have latency requirements as low as 0.74 s (DG-B) and 1.4 s (DG-C). For GEO satellite links already the session initiation would consume a considerable fraction of the maximum latency. Finally the heterogeneous and highly mobile environment, consisting of different link technologies and the belonging different access networks and the need for intra- and inter-technology handovers causes path changes. A change in the end-to-end path would then result also in additional IntServ session re-establishment overheads.

3.3.2 Differentiated Services (DiffServ)

DiffServ [18],[19] is the second well known QoS architecture specified by the IETF. In contrast to IntServ no individual flows can be distinguished but only different aggregated classes of traffic. Instead of a guaranteed forwarding behaviour for every flow, DiffServ defines the per-hop forwarding behaviour for the aggregate classes. For identification of the aggregate, the Traffic-Class field in the IPv6 headers are used. Since in DiffServ only traffic aggregates are treated instead of per-flows, no hard guarantees for the availability of resources and the end-to-end QoS performance can be given. An overdimensioning of resources is thus necessary here in order to meet the QoS requirements. The overdimensioning affects for instance the buffer sizes in the schedulers to avoid packet drops due to buffer overflow but also the available datarates on the links. While in theory the definition of one DiffServ aggregate per COCR CoS would be possible (resulting in 12 aggregates), in practice a smaller number of DiffServ aggregates improves the scalability and reduces the complexity. In this case the application CoS need to be mapped by a classifier into the suitable DiffServ aggregates. Since all COCR CoS have different demands for maximum latency, an aggregation into fewer DiffServ aggregates implies also an increase of the required bandwidth, since the latency of the most demanding service in a DiffServ aggregate has to be met since DiffServ is not distinguishing within an aggregate. In other words services which could tolerate a longer latency need to be transmitted in fewer time (i.e. the time of the most demanding service) what results in a higher demand in terms of data rate. For a DiffServ QoS approach also appropriate estimation and dimensioning of the network capacities is essential and requires a good model for the prediction of the amount of traffic to be transported including an additional buffer for unexpected traffic bursts. Such an (over)dimensioning on the other hand can also mean a waste of resources if capacity is strictly allocated per aggregate class and cannot be shared among different aggregates and considering the highly bursty traffic profile. On the other hand a DiffServ architecture has significant advantages over an IntServ approach which outweigh the aforementioned drawbacks. Most important of all the issues with scalability do not exist here since only aggregates have to be treated instead of single flows. DiffServ is such much more suitable for the highly populated global ATM network under consideration with respect to this. Moreover a change of the end-to-end path, as can happen due to intra- and inter-technology handovers is not an issue here since no re-establishment of the RSVP tunnels is required anymore. Also the signalling overhead of IntServ for session initiation and keepalive can be saved while saving also the time for flow establishment which is beneficial for the overall delay profile.

3.4 Conclusions on QoS Architecture

A flow-oriented architecture such as IntServ would have the feature of guaranteeing a certain end-to-end behaviour, but is not suitable w.r.t. the bursty traffic profile, having only spurious transmission of single messages which have also only small size. The signalling overhead is considerable w.r.t. the small message payloads and also the additional time demand for a session initiation is considerable w.r.t. the latency requirements. A flow-oriented QoS architecture such as IntServ is thus no preferable solution for application in an ATM. The alternative QoS architecture matching better with the given scenario is thus DiffServ. For deployment of a DiffServ QoS architecture several design parameters have to be kept in mind, in particular the correct dimensioning of the resource trunks, mapping of application CoS into aggregate classes and priority scheduling. The main benefits here are the scalability also for a large and global ATM network. Also a change in the network point of attachment, e.g. due to a handover are not an issue here. The data volume and signalling delay overheads of IntServ can be saved here as well. For an integration of operational with non-operational services in the same network, however further specification of the mechanisms ensuring a safe separation of these two domains and appropriate mechanisms for CC, CAC and flow control of the non-op services need to be specified. This work is currently under definition within SANDRA.

4 Summary

In this perspective paper, the demands on an integrated aircraft communications system were laid out. Within the EU Project SANDRA a concept for a functional network architecture is developed which satisfies these requirements. The architecture was presented from a topology level and then there was a focus on the airborne architecture which is the core of the SANDRA network functional architecture. Furthermore, QoS mechanisms were discussed and summed up in detail.

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aircraft communications for global aircraft operations). The project has 31 partners and started on 1st October 2009.

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