AIRCRAFT DATA NETWORKS – INTEGRATED SYSTEM

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Summary: Aircraft data networks are fast becoming more of a necessity due to their support for user mobility. Many aircraft manufacturers are planning to deploy data networks within their airplanes and provide internet connectivity to their passengers. While a data network within the aircraft and passenger access to it causes some security concerns, it open up some safety enhancement opportunities. With internet connectivity within the airplane, the activity within the airplane can be monitored in real-time from the ground station. Also, using the high bandwidth satellite links, the flight critical data could be downloaded to a server in the ground station in real-time flight or periodically, thereby enabling real-time flight status monitoring.

Key words: Modeling, air data, service network

INTRODUCTION

Organizations are moving, or must move, from today's relatively stable and slow-moving business networks to an open digital platform where business is conducted across a rapidly formed network with anyone, anywhere, anytime despite different business processes and computer systems. The potential of the new business network approach is to create these types of products and services with the help of combining business network insights with telecommunication capabilities.

The business is no longer a self-contained organization working together with closely coupled partners: it is a participant in a number of network where it may lead or act together with others.

The network includes additional layers of meaning-from the ICT infrastructures to the interactions between businesses and individuals. Rather than viewing the business as a sequential chain of events (a value chain), actors in a smart business network seek linkages that are novel and different to create remarkable, better than usual results. Smart has a connotation with fashionable and distinguished but can also be somewhat short lived. What is smart today will be considered common tomorrow. Smart is therefore a relative rather than an absolute term. Smartness means the network of cooperating businesses can create better results than other, less smart, business networks or other forms of business arrangement. To be smart in business is to be smarter than the competitors just as an athlete who is considered fast means faster than the other competitors.

The pivotal question of smart business networks concerns the relationship between the strategy and structure of the business network on one hand and the underlying infrastructure on the other. As new technologies, such as RFID, allow networks of organizations almost

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complete insight into where their people, materials, suppliers and customers are at any point in time, the organizations are able to organize differently. But if all other players in the network space have that same insight, the result of the interactions may not be competitive. Therefore, a first critical step is to develop a profound understanding about the functioning of the business network.

1. A NEW BUSINESS NETWORK APPROACH

Each business network participant has specific capabilities captured in its business processes (own business logic) that it executes according to this logic. Traditionally, when such participants combine they create interfaces between capabilities: translating from one business logic to another and executing accordingly. This can be seen in the outsourcing phenomenon: carve out the total function of a particular business operation and hand it over to another party. As indicated earlier, traditional business network approaches lack the ability to rapidly pick, plug, and play to configure rapidly to meet a specific objective, for example, to react to a customer order or an unexpected event. Its focus is on the actors and relationships from manufacturers via multi-modal transportation (road, train, sea ship) to retailers. In most current business networks, companies are developing capabilities at the logistics layer and the transaction layer. The actor platforms are dominated by information silos residing either in different places within an organization as islands, or in two or more different organizations. Individual actors are orchestrating processes in their part of the supply chain. The central idea is that linking partners is on the basis of linking processes but allowing individual execution according to those processes: they act individually according to the joint rules of the network. The network separates process from execution. It shares the processes required to achieve its goals (the shared business logic) allowing each participant to execute in its own way according to this logic. This means that, to be a member of the network, an organization must be able to absorb the shared logic and execute accordingly. This is the own business logic of the network that can be enabled by a Networked Business Operating System (BOS). Based on the service-oriented architecture it resolves the problem of information silos by loose coupling of underlying systems, which are connected together in a business operating layer. This layer allows process execution and management from a distance from the underlying application systems. The enabling inter-organizational technology architecture must reflect this loose coupling. Loose coupling is not synonymous with decentralized processes. It is quite the opposite, where the processes are more tightly coordinated because the rigidity of the IT architecture is no longer a constraint.

Organizations are moving, or must move, from today's relatively stable and slow-moving business networks to an open digital platform where business is conducted across a rapidly formed network with anyone, anywhere, anytime despite different business processes and computer systems. Table 1 provides an overview of the characteristics of the traditional and new business network approaches. The disadvantages and associated costs of the more traditional approaches are caused by the inability to provide relatively complex, bundled, and quickly delivered products and services. The potential of the new business network approach is to create these types of products and services with the help of combining business network insights with telecommunication capabilities. The business is no longer a self-contained organization working together with closely coupled partners: it is a participant in a number of networks where it may lead or act together with others. The network includes additional layers of meaning-from the ICT infrastructures to the interactions between businesses and individuals. Rather than viewing the business as a sequential chain of events (a value chain), actors in a smart business network seek linkages that are novel and different to create remarkable, better than usual results. Smart has a connotation with fashionable and distinguished but can also be somewhat shortlived. What is smart today will be considered common tomorrow. Smart is therefore a relative rather than an absolute term. Smartness means the network of cooperating businesses can create better results than other, less smart, business networks or other forms of business arrangement. To be smart in business is to be smarter than the competitors just as an athlete who is considered fast means faster than the other competitors.

The network coordination is highly automated. On a repair order no one needs to intervene unless an exception occurs. The BOS tracks more than 100 variables to assure quality standards and timely execution. With this automated coordination, productivity increased to 49,6% and the number of errors dropped dramatically. The firm has automated almost all human communication except for incoming calls. Therefore the CSR-s do not manage phone calls, they monitor the processes to manage exceptions to ensure quality. With the intense use of ICT, particularly Web services, connected and disconnected processes have been integrated and standardized. Rather than technological, a major challenge in implementing the BOS has been ensuring trust with the agents given the higher levels of standardized processes and transparent control. The BOS also has the capacity to adapt to environmental changes by defining behavioral limits as automatic responses or human-driven actions for exception management. The BOS also accommodates idiosyncratic corporate customer demands as turnkey services. All services are audited through SLA-s with all agents in the network. Multi-asistencia has also boosted value and innovation by collaborating with its corporate clients [2, 3]. Approximately 80% of new software development has been done in collaboration with its large customers. For example, in 2005, it created a new desktop tele-survey adjustment service. When the repair assessment exceeds a financial threshold, loss adjusters can carry out a desktop audit on the Internet; digital photographs are taken on-site by trade professional send to the CSR, and reviewed for approval in real time.

2. RELATED WORK ON LOCATION MANAGEMENT

Existing PCS networks typically cluster groups of cells into *registration areas* (RA), such that the location uncertainty of an MN is confined to its last reported RA. In this approach, an MN performs proactive location updates only when it changes its current RA, and not on every cell-change. In general, location update strategies can be classified into three categories:

- distance-based,
- movement-based,
- time-based;

3. SYSTEM DESCRIPTION AND LOCATION UNCERTAINTY

The topological layout of an integrated network in Fig. 2 shows that the coverage area of an individual sub-network can be discontinuous (e.g., a set of disconnected islands of 802.11-based hot-spots). Accordingly, the set of sub-networks that can be accessed concurrently by an MN is not constant, but a function of its current location. Mathematically, let the integrated network consist of *N* sub-networks or access technologies $\{S_1, S_2, ..., S_N\}$, where each sub-network is a collection of (either partitioned or overlapping) cells. Let C_i^j represent the *j*-th cell in the *i*-th sub-network S_i, and let $|S_i|$ represent the cardinality of (number of cells in) S_i. The location of an MN at any instant can then be represented as a vector-valued random variable $\overline{X}$ of dimension *N*, where the *i*-th element of the vector corresponds to the current cell of sub-network S_i. For example, if $\overline{X}(2) = 4$, the MN is currently located in the fourth cell of sub-network S_2. As some of the sub-networks may be hotspot-based (e.g., 802.11), thus providing isolated islands of coverage, an MN may frequently roam outside the coverage of a specific individual sub-network. For notational convenience, let each sub-network have an additional cell ϕ to capture this disconnected state. Accordingly, if the MN is currently out of coverage of S_i, its location vector includes the cell C_i^{ϕ}. To model the multi-system environment, where different sub-networks may have different paging and location update costs per transmitted message, let PG_i represent the cost of transmitting a single paging message in a single cell, and let LU_i be the cost of transmitting a single location update message in a cell of the *i*-th sub-network S_i.

Similar to the LeZi-Update scheme [9], our location update strategy views the MN's movement pattern as a sequence of symbols and issues location updates, not at each movement of the MN, but only on an appropriately determined (entropy - coded) subset of this movement sequence. While the LeZi-Update scheme can be applied to movement - based strategies, time - based strategies, and distance - based strategies, without loss of generality, we consider a movement - based location update strategy where a new symbol is generated only when the MN changes a cell in any one of the sub-networks.

The probability of finding the MN in a specific location can be modeled by the joint probability distribution

$$\Pr\left(\overline{X} = [x_1, x_2, x_3, ..., x_{N-1}, x_N]\right)$$
$$\Pr ob\left(MN\, is\ located\ in\ C_1^{x_1} \cap C_2^{x_2} \cap C_3^{x_3} \cap ... \cap C_N^{x_N}\right) \quad (1)$$

where x_i represents the MN's cellular coordinate in S_i. Note that one or more of these elements may have the value ϕ. The movement of an MN may then be viewed as a stochastic, vector valued process

$$\chi = \{X^n\} \tag{2}$$

which would then be associated with an entropy bound $H(\chi)$, formally defined as

$$H(\chi) = \lim_{n\to\infty} H\left(\overline{X_n} / \overline{X_0}, \overline{X_1}, ..., \overline{X_{n-+}}\right) \tag{3}$$

Where

$$H(\chi) = -\sum_{\bar{x}\in\chi} \Pr(\bar{x}) \lg[\Pr(\bar{x})] \tag{4}$$

Since the vector-valued entropy in (3) does not account for the fact that different update/paging messages (corresponding to different sub-systems) have different costs, we propose the concept of weighted entropy or the minimum weighted cost per movement. Note that, for the movement - based location update, the random vector $\overline{X_n}$ differs from the random vector $\overline{X_{n-1}}$ only in one element, i.e., an MN changes its cellular coordinate in only one sub-network at a time. Ideally, the MN informs its location update to a centralized location tracking system using the sub-system S_i where it has changed cells, thereby incurring an update cost of LU_i. The cost of conveying an information change in the *i*-th element of the random vector $\overline{X}$ is thus weighed in proportion to the associated update cost, LU_i. Accordingly, the weighted entropy is given by

$$H_w(\chi) = -\lim_{n\to\infty} \sum_{i=1}^{N} LU_i * \sum_{j=1}^{|S_i|} h(n,j) * \log_2 h(n,j) \tag{5}$$

with

$$h(n,j) = \Pr\left[\overline{X_n} = \left(..., C_i^j, ...\right) / \overline{X_{n-1}}, ... \overline{X_0}\right] \tag{6}$$

where the … imply that the corresponding random variables can take any possible value within its range. This weighted entropy measure is not of direct relevance to our update strategies which employ multidimensional Lempel-Ziv (LZ) compression without any apriori knowledge of the underlying movement statistics of the MN. The weighted entropy value $H_w(\chi)$ merely captures the true theoretical lower bound on the signaling cost that any feasible location update strategy must incur.

CONCLUSION

We have proposed an information-theoretic location management strategy for emerging multi-system wireless networks.

The framework is powerful as it exploits the correlation in the user's location (and in some cases, its calling pattern) across individual sub-networks, without requiring a public global database. We have developed the concept *of weighted entropy*, as the most fair measure of location uncertainty of the mobile node (MN) in heterogeneous sub-networks.

REFERENCES

(1) VOLNER, R., BOREŠ, P. ATN Networking – Policy based Management for Enterprise and Carrier, *27th International Conference on Information Technology Interfaces ITI 2005*, Cavtat/Dubrovnik, Croatia, June 2005, pp. 37-38, ISBN 953- 7138-04-6

(2) VOLNER, R. Aviation Data Networks – New Avenues for Flight Safety, Security Issues and Network Architecture, *27th International Conference on Information Technology Interfaces ITI 2005*, Cavtat/Dubrovnik, Croatia, June 2005, pp. 35- 36, ISBN 953- 7138-04-6

(3) VOLNER, R., SMRŽ, V. Architecture IP and Information Technology for Air Company, *31th International Conference on Information Technology Interfaces ITI 2009*, Cavtat/Dubrovnik, Croatia, June 2009, pp. 43-44, ISBN 978-953-7138-16-5, ISSN 1334-2762, IEEE Catalog Number CFP09498-CDR

(4) TICHÁ, D. A Sensitivity Approach in Digital Filter Design, *3rd International Workshop Digital Technologies 2006*, Žilina, 2006, ISBN 80-8070-637-9

(5) AKYILDIZ, I., F., WANG, W. A dynamic location management scheme for next-generation multitier PCS systems, *IEEE Trans. Wireless Commun*., vol. 1, no. 1, pp. 178–189, January 2002

(6) BAR-NOY, A., I. KESSLER, I. Tracking mobile users in wireless communication networks, *IEEE Trans. Inf. Theory*, vol. 39, no. 6, pp. 1877–1886, November 1993

(7) VOLNER, R., BOREŠ, P. Aviation Data Networks, *Electronics and Electrical Engineering No 7(63)*, Kaunas University of Technology, Academy of Sciences of Lithuana, Vilnius Gedimas Technical University, Riga Technical University, Tallinn Technical University, Kaunas 2005, pp. 22-26, ISSN 1392-1215

(8) BEREZDIVIN, R., BREINIG, R., TOPP, P. Next-generation wireless communications concepts and technologies, *IEEE Commun. Mag*., vol. 40, no. 3, pp. 108–116, March 2002.

(9) *ITU-T, Study Group 8; T.120*: Transmission Protocols for Multimedia Data; 20 March 1995

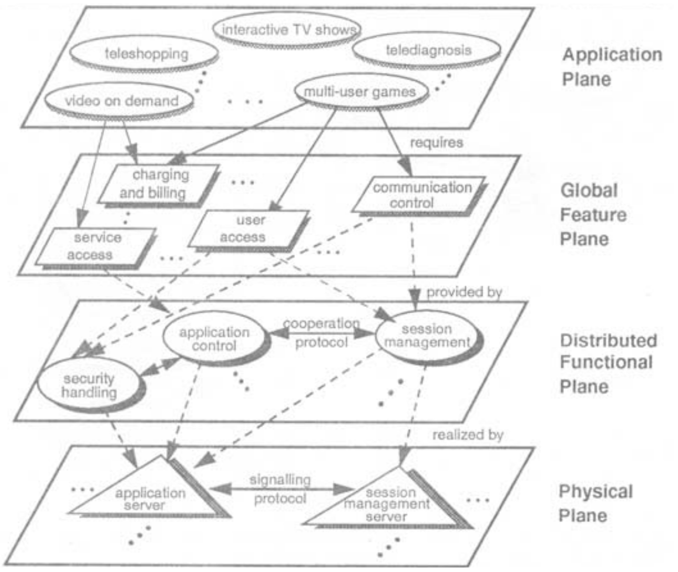

Fig.1 - Data service reference model

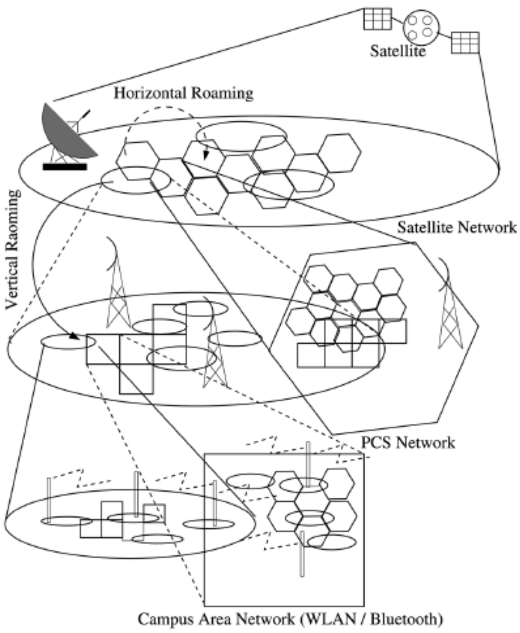

Fig.2 - A multi-system heterogeneous wireless network