INTELLIGENT RECONFIGURATION OF WIRELESS MOBILE NETWORKS

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ABSTRACT

The paper describes development of a generic architecture for the intelligent reconfiguration of the wireless mobile networks within the EC funded Framework V CAST Project. The CAST demonstrator, currently being developed and integrated, is intended to evaluate some of the fundamental concepts of the proposed architecture, within the technological constraints presently available. Here, we present a generic distributed architecture and discuss problems associated with the organic-based intelligent support, network management, resource optimisation and control, and object orientated reconfiguration of resources.

1. DISTRIBUTED APPROACH

Figure 1 shows the proposed architecture. In this design, the distributed intelligence has the following components:

a) Global Intelligent Reconfiguration Controller (GIRC), located in the Mobile Switching Centre (MSC)
b) Locall Intelligent Reconfiguration Controller (LIRC), located in each Base Station Controller (BSC) and each Mobile Station (MS)

The GIRC contains the global components of the Network Manager (NM), and the organic based CODA intelligent support sub-system, which share a database. Each LIRC on the other hand, contains the local components of the Resource Controller (RSC), and the Network Manager, both of which have access to the same database. It is assumed that NM is forced to perform a reconfiguration of the whole or part of the network due to one of the following events:

a) A service request that was received from the Service Manager (SM), which requires the reconfiguration of the network resources.

b) A failure message was received via the Fault Manager (FM), which requires remedial action in the form of some reconfiguration.

The reconfiguration is decided by the Network Manager, in consultation with CODA, via the shared database, and the reconfiguration task is then analysed and passed to the local LIRCs in each corresponding BSC and MS modules. The Layer Controller (LC) in each layer is responsible for the processing of the reconfiguration procedures, normally by forming and executing the required object chains.

2. INTELLIGENT SUPPORT SYSTEM

The Complex Organic Distributed Architecture (CODA) is an architecture which leverages the data that can be stored in databases and warehouses. CODA provides intelligent information to a system by using data marts in a layered distributed deployment. These layers are based on Beer’s division of the work performed in organisations on organic lines [1]. Filters and wrappers make sure that each component only receives necessary and sufficient information. The critical success factors (CSF) allow components to act with a degree of autonomy [2].

Operating information is collected for a preset timeband, typically every three hours. The time band must be long enough to allow the higher layers to collect data in sufficient quantity regarding the type of devices available, the required service and user locations. The Network Manager and the Reconfiguration Controller both download copies of the updated information on the best performing configurations for the time of the day and the type of calls required. This is stored in look up tables, which are closely monitored and regularly updated. CODA software at the monitoring operations layer is constatly assessing the transactions passing through the network. If a transaction is successful, this is noted. However, failed operations and reconfigurations always alert the higher layers and may result in some immediate changes. Otherwise the system regularly updates the look up tables on the basis of its analysis of the historical data. For further improvement in performance, CODA also alerts the Network Manager and Reconfiguration Controller if there is any predicted shortfall in the provision of services and suggests possible reconfigurations based on analysis of past performance, current failures and current events.

At the ´monitoring operations` and the ´monitoring the monitors` layers, the reconfiguration performance is improved by comparing predicted performance for the time band and current (actual) performance data. In addition, the history data about the performance of the network is stored in a very large data warehouse in the monitoring the monitors layer containing three months past performance data. The software then outputs predicted performance data with suggested service chain data.

3. OPERATIONS AND INTERFACES

In the CAST project the reconfiguration process requires some intelligence because the service requirements are constantly evolving and because the service provision varies. Moreover, the provision of a service can involve reconfiguration of the mobile station, base station and mobile switching station for effective service provision.
The CODA layers designed in the CAST project have been built to include software to assist in making the best possible selections for the reconfiguration of each mobile network. Figure 2 shows the general structure of CODA [3]. Figure 3 shows the CODA distributed architecture whereby the MS, BSC and MSC are able to filter calls independently, thereby minimising traffic across the network. The call buffer acts as a protocol.

The MS can request a service providing the service requested is permitted by the user profile, the base station will let this call through providing there is sufficient actual and predicted bandwidth. The call buffer acts as a protocol. The MS can request a service providing the service requested is permitted by the user profile, the base station will let this call through providing there is sufficient actual and predicted bandwidth.

Operating information is collected for a pre set timeband. In the CODA database design this has been set to every three hours but can be modified. The time band setting has been designed to allow the higher layers to collect data in meanigful chunks. Three hourly timebands to allow the CODA analysis software to deduce behaviour patterns typical for the timeband and to bradcast predictions for the next simlar timeband.

The Network Manager and the Reconfiguration Controller both download copies of the updated information on the best performing configurations for the time of the day and the type of calls required. This is stored in look up tables, which are closely monitored and regularly updated. Ideally, CODA should be able to make sensible predictions about network usage for a particular location and timeband.

CODA software at the monitoring operations layer is constatly assessing the transactions passing through the network. If a transaction is successful, this is noted. However, failures and reconfigurations always alert the higher layers and may result in some immediate changes. Otherwise the CODA system takes regular three-hourly downloads of service performance and updates the look up tables on the basis of its analysis of historical data.

For further improvement in performance, CODA also alerts the Network Manager and Reconfiguration Controller if there is any predicted shortfall in the provision of services and suggests possible reconfigurations based on analysis of past performance, current failures and current events.

At the monitoring operations and the monitoring the monitors layers of CODA for the CAST project, the reconfiguration performance is improved by comparing predicted performance for the time band and current (actual) performance data.

At the monitoring the Monitors layer, historical data about the performance of the network is stored in a very large data warehouse containing three months past performance data. The software outputs and one month of predicted performance data with suggested service chain data.

CODA intelligence is based on the constant seeking of best performing chains. The analysis is performed using dimensional analysis. The software closely analyses failures to operate within the tolerances defined in the critical success factors. On the basis of analysis it is able to offer advice on how to proceed.
Advice may be non-critical, such as suggesting the system offer a lower level of service. In certain rare instances, CODA may be able to recognise imminent catastrophe and offer high priority advice, which should be taken to prevent systems failure.

The priority weighted feedback loop mechanism, whereby failure triggers an alert and success is simply registered as normal operation, mirrors the operation of coenetic variables in organic systems. In the two intelligence layers, the distributed operational data is brought together in the call histories. However, for the system to be effective, the data in the call buffer needs to be dimensionalised when sent to the monitoring layers. Dimensional information allows the system to analyse failure by type, by location, by service, by user type and by handset type (to name a few possible queries). The queries allow the system to fine performance using the minimum data transfer because updates are transmitted only to those areas of the network which are underperforming.

In theory, a CODA system provides the evolutionary capability required for complex intelligence. In the CAST project the system is adaptable in two ways.
Firstly, analysis of the network performance trends using the timeband data ensures that the performance of the system will improve and fewer calls on the intelligence will be made. CODA software is designed to make the performance of the network more streamlined and effective by weeding out poorly performing service chains and even under used services.

4. CAST DEMONSTRATOR SYSTEM

Figure 4 shows the configuration of CODA in the CAST Project demonstrator, using Oracle 9i deployed on Microsoft Windows 2000 Server. Three layers of the architecture have been designed and partially implemented, which perform the 'monitoring the monitors' function, and are used to manage intelligent reconfiguration of services for the mobile network. The data warehouse requires full OLAP functionality and this is performed in the demonstrator by the Oracle Warehouse software. The warehouse represents the actions of the MSC in the provision and reconfiguration of services and adds sufficient functionality to provide the system with some intelligence. The enterprise management level in the configuration is transparent to CODA.

In the demonstrator we do not differentiate between the BST and the BSC. Nevertheless the functionality performed at node 2 involves both managing and monitoring operations.

Further structure is given to the data by managing it through interface classes such as wrappers and filters [5]. These are developed using Java and IDL. For this reason the design is expressed in UML. Some GUI interfaces are currently under construction which will allow the operators to view the behaviour of all elements of the system.

5. CONCLUSION

In conclusion, a generic distributed architecture was described, for general reconfiguration of wireless mobile networks. In this design, problems associated with the organic-based intelligent support, network management, resource optimisation and control, and object orientated reconfiguration of resources were investigated and discussed.

ACKNOWLEDGMENT

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REFERENCES

[1] R. Espejo, R. Schuhmann, W. and M. Schwaninger, Organisational Transformation and Learning, A Cybernetic Approach to Management. Wiley, 1996.

[2] T. Karran, G.R. Justo, M. J. Zemerly An Organic Architecture for component Evolution in Decisions Systems, SCI2000 Conference Proceedings July 2000.

[3] Tereska Karran, George Justo, Kambiz Madani: "Intelligent Reconfiguration of Large Mobile Networks using Complex Organic Distributed Architecture" VTC-Spring Conference, Rhodes - Greece, 6-9 May 2001.

[4] G. R. Justo, S Imre, T Karran, J. Kovács: "Intelligent Decision-making within 4th Generation Wireless Networks", International Conference on Internet Computing (IC'2001), June 25-28, 2001, Las Vegas, USA.

[5] R. Ribeiro Justo, G. R. and P. Cunha. An Architectural Application Framework for Evolving Distributed Systems. Journal of Systems Architecture: Special Issue on New Trends in Programming and Execution Models for Parallel Architectures, Heterogeneous Distributed Systems and Mobile Computing, Vol. 45:1375-1384, 1999.

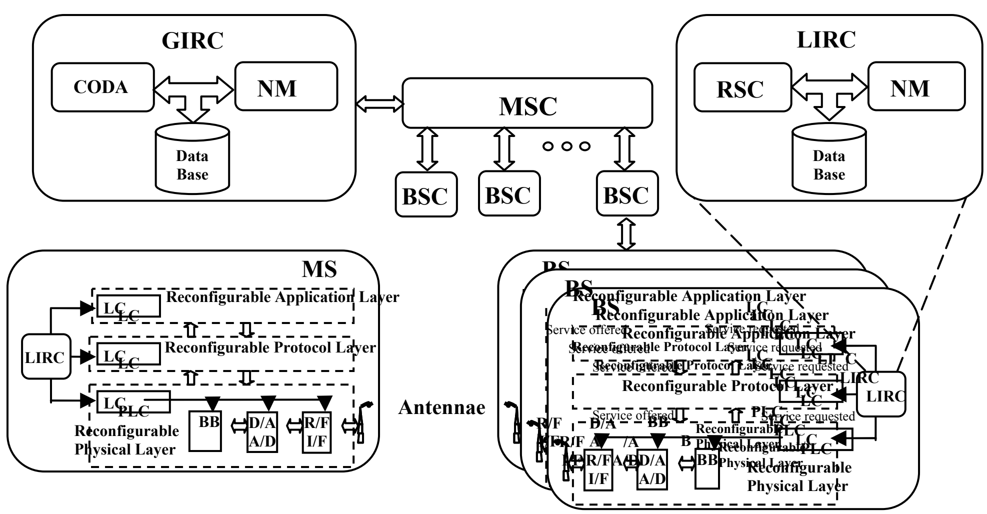

Figure 1: The Proposed Distributed Architecture

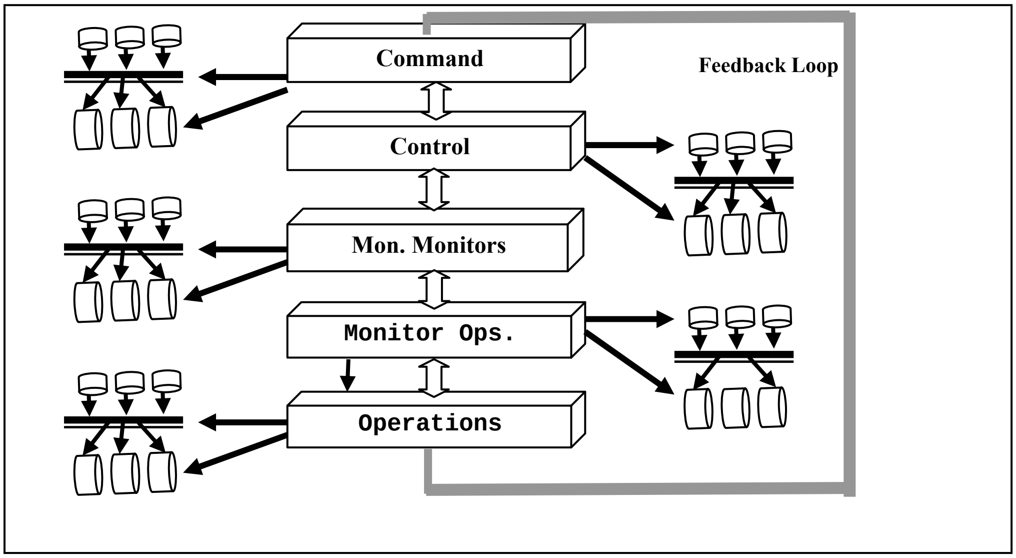

Figure 2: CODA Architecture

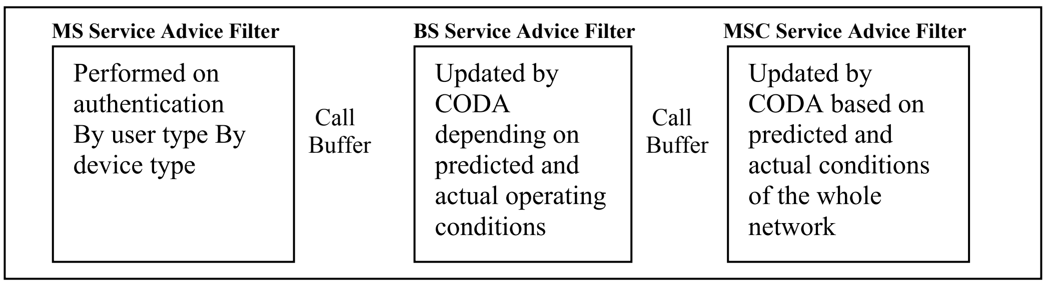

Figure 3. CODA Filters

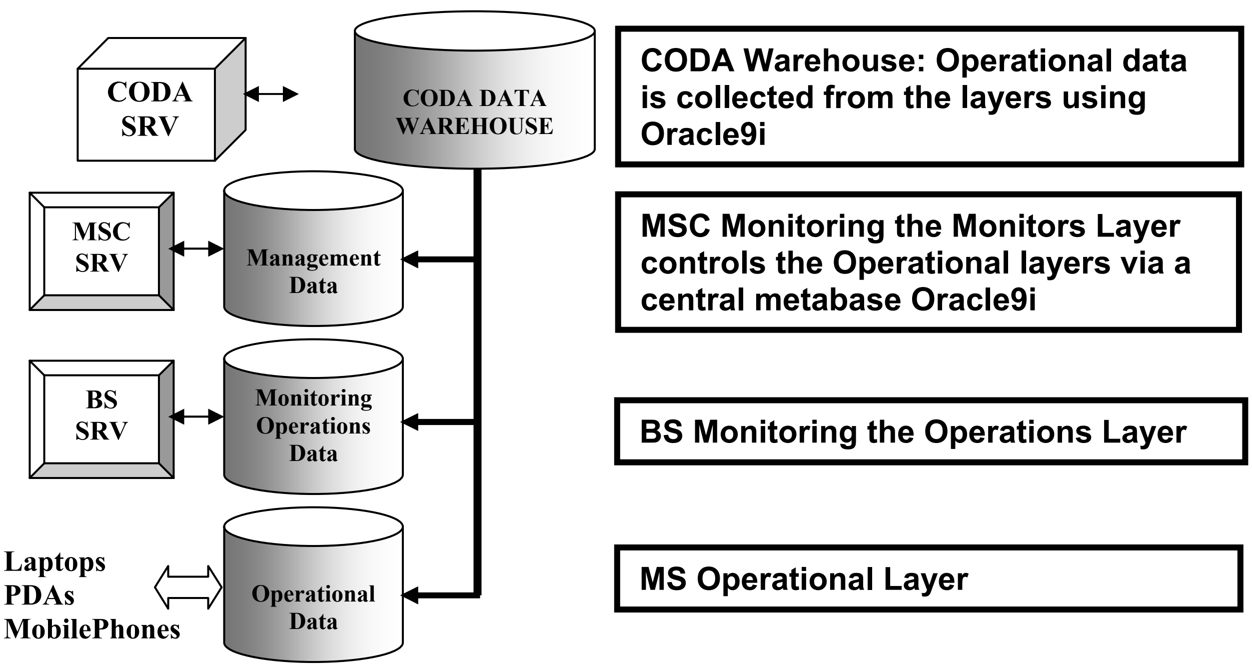

Figure 4: Demonstrator System