Embedded and Distributed Real-Time Systems Software Engineering Programme (EDSSE)
Projects proposed in the Electronic Systems Laboratory and the Stellenbosch Telkom COE in the application area of Data telecommunications

Department of Electrical and Electronic Engineering
University of Stellenbosch

Project Leader: Mr Sias Mostert

Rational

More and more processors are embedded into systems. The need for dependable systems and reliable software is easily understandable in such a context. Telecommunication systems are of particular importance as it permeates society in more and more forms. Dependable systems are required in satellite systems and a satellite provides a good vehicle for developing and deploying dependable systems. Terrestrial telecommunication systems are however advancing faster as the wireless revolution is taking place.

Objectives

Grow expertise, technology and a toolkit for the reliable engineering of real-time software systems including the communication subsystems with application to open secure distributed real-time systems such as the SUNSAT micro satellite and its ground station. The techniques, technology and toolkit are also applicable to other systems. The particular architecture in which the research for distributed and embedded systems are done is a data flow/message passing architecture.

Methods

Research and development can be optimised if the following three aspects are co-ordinated.

1. Research area – this represents timeless or slow changing principles of physical phenomena and mathematical techniques. This expertise is normally maintained and built up in an academic research group.
2. Technology/standards/systems – this represents the physical realisation of particular phenomena based on political processes (standards), current state of development (technology) and actual systems that have been decided upon or implemented (eg. voice switch network/packet switch network).
3. Products/Artefacts – this represents the actual artefacts/products that embodies the technology of the day, satisfies the standards that were set for such a particular item and which can find their way into the systems of the day that are deployed.

The method proposed for this research project is a balance of the above where the research area is real-time software engineering, the technology/standards/systems are that which is used in software engineering (for dependable systems) and telecommunication systems (ie WAP) and the products/artefacts relate to satellite telecommunications.

The following table describes the research areas, applicable standards and the expected outputs from this project over the next two years.

Research areas						
Technology /Standards/ Systems	Processor architectures	Software architectures	Protocols and modulation	Network management	SW Engineering and architectures	Valorisation of technology/ systems and intellectual capital
Intelligent IO	Reliable DSP processor module with enhanced IO Tool: Synopsis				Establish and researching software engineering practices and processes for creating dependable software	
Embedded JAVA		Establish and evaluate embedded JAVA environment Tool: Rose RT				
AX.25, GSM, WAP			Establish satellite communication gateway Tool: SDL			
Access Networks	Inexpensive VHF access networks for school applications		DSP modem for satellite data transmission			
XML				Micro satellite data management and mission planning Tool: JBuillder		
SA Telecommun ication Engineering base						Establish value of engineering base applicable to telecomms developme nt and deployment in SA.
Product output	HW – processor module RF demonstration modules	Embedded Java environment	AX.25, GSM RLP, WAP? Gateway implementations	Generic telemetry and telecommand database and client	Process techniques and maintainable software	Audit and opportunity matrix
Document output	Thesis1 Dec 2000 and Thesis 2 Dec 2001	Thesis Dec 2001	Thesis Dec 2000	Thesis Jun 2000	Technical report	Technical report

Active research tasks

Satellite communication networks provide a unique solution for rapid deployment of access networks into under supplied areas. The satellite network bandwidth is limited and a single satellite system solution does not match the expectations of all applications. In particular the application of satellite communication networks for distributed computer networks provide unique challenges as satellites often represent resources of variable availability. The satellite communication research project track of the EDSSE program addresses the satellites communication links for data transfer to better understand the characteristics and application of these low earth orbiting satellites links for the distributed EDSSE architecture across satellite network WANs.

a) The development of a data link between a satellite gateway and low earth orbiting satellites with a data rate of between 19200 to 56000 bits per second which supports the EDSSE architecture for distributed real-time communication and computation. The data link is for full duplex communication between a ground station and a low earth orbiting satellite. The task will begin with the evaluation of existing data links between satellites and ground stations. This will be followed by a system analysis of the improvement of the performance of a data link with the subsequent development and prototyping of the proposed improved link. The data link will finally be evaluated to determine its performance and support of the EDSEE architecture for real-time communication.

b) The effective operation of the SUNSAT microsatellite, in addition to the automation of the ground station, calls for the creation of a data-management and mission-control architecture. This project encompasses the design and implementation of the various satellite and ground-based technology components that will together comprise such a system. Specific research areas involved include database systems, distributed system engineering, communication protocols and remote application services.

   Technology to be explored in the realisation of the above system includes: Software patterns for distributed systems within a distributed message queuing architecture. Software patterns for control architectures in distributed systems including:

   1. Event managers which includes a generator and subscriber model
   2. Distributed message queuing within a producer/consumer model
   3. XML data modelling and interchangability for application in an autonomous satellite groundstation and other distributed processing environments such as distributed intelligent instrumentation and secure transaction systems.

c) Develop an embedded Java version of the real-time kernel which are currently successfully applied in the SUNSAT micro satellite. This would include porting it to a pre-emptive kernel running in protected mode operation on a 386EX, porting the libraries en environment for multiprocessor operation within the message queuing architecture framework. 386 low overhead kernel RTXn to support flat mode programs and extended to support compiled Java code for high performance telecommunication software in satellite telecommunication applications. (HV)

d) Evaluate DSP processor core for telecommunication function module realisation. Investigate key IO topologies for performance enhancement and possible application in satellite telecommunication subsystems.

e) Establish low cost VHF transmitter and receiver modules that can be deployed in applications that are very cost sensitive such as school access to satellite data networks.

Future research tasks

f) Switching and routing for closely coupled embedded systems with variable bandwidth communication requirements supporting the EDSSE architecture. In particular low data rate, high reliability communication and high bandwidth communication will be considered. The trade off between switching and routing will be investigated for system parameters such as real-time response, fault tolerance and remote management. The techniques will be tested on a satellite ground station and a high performance bus for application in satellite ground stations and micro satellites.

g) Develop a mission planning system for the distributed system including SUNSAT and its ground station. This would include studying mission planning systems, the SUNSAT requirements and distributed system calendar systems and then creating an environment with which satellite missions such as SUNSAT can be planned and commanded.

h) Evaluate the high speed satellite communication S band data link on SUNSAT for image transmission and develop an improved data link suitable for X band operation.

i) The development of a high bandwidth communication link between a moving object and a ground station. This includes the stabilised antenna platform, high bandwidth (up to 100 Mbps) modulation and microwave frequency system engineering (X band). These links are typically required for the feeder links to the new generation LEO broadband satellite constellations and its ground stations or between high flying aircraft which provides emergency communication for a particular geographic area. A return path for control information is included in the scope of the project.

j) Towards formal verification of software constructed with a function block set. Society increasingly uses computer based systems for communication systems and control and automation functions in safety critical applications. The problem of software dependability becomes more and more virulent. In the form of function block diagrams, software can graphically be composed from small sets of high level application oriented modules. This joint work will investigate different methods of specifying such function blocks and, based on their relative advantages and disadvantages, lead to recommendations regarding suitable forms for these specifications which will meet the needs of both the engineers using these function blocks and the engineers certifying and verifying them.

k) VOIP, modelling satellite network, implement an on board processor which is detached from the main processor and to ground terminals which can handle voice or data. Access network with VOIP terminals for data or voice access to LEO satellite. Perhaps to support remote video terminals downloading images from SUNSAT constellation anywhere in the world. (RB)

l) Evaluate ARM processor core for satellite applications with integrated SCC also to support VOIP ground terminal. Also look at making ARM core radiation tolerant in its implementation.

m) Investigate the implementation of third generation protocols implemented on a base station (satellite) and mobile handsets (field stations). This should include the mobile handset and the software engineering processes facilitating short development time and dependable software.

n) Ground station automation based on a Linux platform. Investigate the use of public domain technologies to implement mission critical systems.

o) Investigate the application of fifth generation graphical programming environments based on rigorous underlying principles to build satellite communication software such as for SUNSAT. Use tools such as Rose Real Time, ObjectTime and SDL to evaluate the application of these tools for developing mission critical software.

Human resource development

The students involved in the project are below.

a) Reliable DSP processor module with enhanced IO
Mr H Berner (Masters year 1)

b) Establish and evaluate embedded JAVA environment, Tool: Rose RT
Mr H Venter (Masters year 1)

c) Establish satellite communication gateway ,Tool: SDL
Mr A Cardoza (Masters final year)

d) DSP modem for satellite data transmission
Mr D Leber (Diplomarbeit)

e)Micro satellite data management and mission planning, Tool: Jbuillder
Mr B van der Merwe (Masters final year)

f) Establish and researching software engineering practices and processes for creating dependable software
Ms H Ludick (Research Assistant)

Team leaders: Sias Mostert, Prof GW Milne and Dr MM Blankenberg

Corrective action

Mr Cardoza is a coloured male
Ms Ludick is a white female

Industry collaboration and networking

Institution	Involvement
Telkom	Manpower development, equipment, software, books and forums
Sun Space and Information Systems	Research assistantship
Nikon systems	Deployment and evaluation of telecommunication systems
Leocell	Satellite communication telemetry system evaluation
Fern University Hagen, Germany	Information exchange on the development of dependable systems.

Team for 2000

Sias Mostert, prof GW Milne, dr MM Blankenberg, Ben van der Merwe, Andrew Cardosa , Heinrich Venter, Heiko Berner, Francois Nel, Hermien Ludick, Dirk Leber.

Technology/Tools

The embedded micro kernel is RTXn, with higher level systems running on a combination of Windows NT and Linux platforms. Future tools to be evaluated include Rose Real-Time, ObjectTime, SDL and the use of operating systems such as VXWorks. The real-time and embedded application of JAVA is also to be investigated including JAVA OS running on smart cards.

Conclusion

Software engineering is one of the most practised forms of engineering, but certainly is also a testimony to one of the least understood forms of engineering. This is true judging by the number of software projects/products that are disbanded and the number of flaws in commercially available software. Mission critical systems such as telecommunication systems are of particular importance as communication networks are accepted as part of everyday life.

This project proposal combines the research depth of real-time system software engineering with the most up to date standards/systems/technology to produce artefacts that can form part of the highly visible micro satellite program at Stellenbosch University. In this project all aspects related to optimising the impact of the research are given maximum opportunity of succeeding.