Chapter 13

Conclusions

Authors: Richard Lewis, David Griffin, George Pavlou

CM developed a TMN Testbed tailored to the management of IBC Networks and Services, making use of Advanced Information Processing technologies and conforming to emerging TMN principles and standards, integrated with new research results originating within the project. Although the project has advanced the state of the art in a number of areas of theoretical study, the approach of the project has essentially been a practical one. The work described in this book and, in particular, the conclusions presented here are based on real experience gained through practical work. The theoretical results of the project have been validated through design, implementation and experimentation.

The Testbed comprises a TMN Platform, Management Applications, Real Networks, Network Interfaces, and an ATM Simulator, derived from external technologies integrated with components implemented by the project. ICM addressed a wide range of management scenarios, including performance and configuration management applied to LANs, Access Networks, WANs, and Value Added Services implemented in four Testbed versions. Following implementation and testing, the experimental results were analysed and a number of conclusions were drawn. These conclusions are summarised in the remainder of this chapter.

- Management systems can be used to increase the sophistication of algorithms, such as routing, embedded within the control plane of the network elements. By this method, local algorithms can be made adaptive to network-wide conditions, and to past and predicted events. These enhancements can be made without
imposing additional complexity, and hence cost, into the network elements themselves. The only requirement is that the network elements support a management interface to supply the TMN with the required information, and to allow the TMN to make configuration changes.

- Because the management plane is orthogonal to the control and user planes, the complexity of management systems may be increased almost infinitely to enhance the intelligence of the network and the way it responds to a changing environment.

- ICM proved that it is possible to implement TMN systems based on OSI systems management principles and complying with established TMN architectural concepts and methods. Resulting implementations operated effectively and as specified in various live and simulated network environments, with satisfactory levels of performance.

- The project found that not only was it possible to build management systems according to the OSI management model, but that the OSI approach offered many rich and powerful features to aid and even guide design and implementation. In particular, the OSI Systems Management Functions greatly aided the development of ICM’s TMN systems - the use of object management, alarm management, logging, event reporting, metric objects and summarisation functions provided generic management capabilities which otherwise would have had to be created from first principles.

- The project demonstrated the benefits of hierarchical designs for complex systems. A hierarchical system allows sophisticated but computationally intensive management algorithms to be used without burdening the lower levels of the management hierarchy, or the network elements themselves, with a large management overhead.

- Efficient designs of management systems are facilitated by following a hierarchical approach. Management activities may be delegated down to the lowest levels of the management hierarchy, close to the source of the management information. This allows polling activities and other communications intensive operations to be performed locally, making use of asynchronous event reports for passing pre-processed information back up the management hierarchy to the intelligent management algorithms. This philosophy reduces the need for synchronous information retrieval techniques such as polling (by centralised management algorithms) and thereby reduces the overall communications overhead imposed by the management system.

- The hierarchical system proposed by ICM for VPC and Routing management combines pro-active management with reactive management techniques. For longer time intervals, the more comprehensive management algorithms make decisions based on the predicted usage of the network. On the other hand, lower level management algorithms adapt the configuration of the network to actual usage measured in the network. This combination of techniques allows long term decisions to be made without compromising the short term adaptability of the network. Furthermore it acknowledges that long term predictions are often inaccurate and compensates for these inaccuracies by closely following the actual developments within the epochs of the long term predictions.
CONCLUSIONS

- Advanced tools are required to build such complex systems. ICM developed such tools to provide a range of development and run-time support, publishing its experience to widely. Commercial tools incorporating this experience are now appearing on the market. However practical experience using the tools in complex systems such as those developed by ICM remains limited.

- Implicitly the ICM management platform was shown to be required to provide a generic infrastructure facilitating the construction and development of TMN components. With respect to implementation and deployment, the tools developed within the project have reduced the development time and maximised the reliability of the resulting system.

- The various implementations of the ICM Testbed, over the course of the project have shown that it is possible to reuse the ICM components to develop TMN systems which can be applied to the management of such different network technologies as FDDI, PON and ATM, as well as to the management of higher level services. Evaluation of the experimental results has also shown that the Management Applications developed by the ICM project can have a positive influence on the performance of the networks on which they are applied.

- The TMN architectural concepts and methods, combined with the ICM method of developing OSs, are ideal for distributed implementation and integration. In particular the Object Oriented approach, in which discrete components with defined interfaces are developed, is a key technology.

- During implementation, integration and experimentation, the ICM TMN was exercised in a Pan European context and demonstrated technological and architectural scalability in terms of complexity (level of functionality and number of TMN architectural components), distribution (number of hosts within a TMN site and number of TMN sites), and size (logical and physical network size).

- The ICM Management Applications provide a firm basis for more complex systems. For example VPCM is a sophisticated management system which can be used to support more advanced research into such subjects as ATM charging or route design; the I-VPN system can configure Virtual Paths over multiple domains, and so can provide bandwidth management for Pan European user trials.

- Adaptation, such as the translation between SNMP and CMIP, showed that TMN systems can be integrated with non-TMN devices. In fact this is a strength of the TMN approach permitting legacy, developing, and advanced systems to co-exist. Conformance to standards and use of advanced tools greatly simplified the process of developing network interfaces. In particular the CMIP/ SNMP gateway developed within the project greatly increases the efficiency of the development of interfaces to commercial switches.

- Developing and testing TMN systems with real networks is a complicated process, with a number of technical and non-technical dependencies. Ideally, these dependencies should be reduced as far as possible to enable efficient TMN system development. The project’s ATM Simulator permitted such a reduction, and contributed greatly to the efficiency of the project. It was used during system integration to facilitate the testing and debugging processes. Once tested, the TMN could then be applied to experiments on the real network. Once the TMN
had been validated on the real network, the Simulator was used to further exercise the TMN in more complex networks and conditions. Even when broadband technology and networks are more widely deployed, they will not always be available for the conduct of complex experiments; network owners and operators will be unwilling to permit experimentation on live networks; even access to experimental networks will continue to be restricted. A mode of working based on the use of advanced simulation, is certain to offer significant benefit even once broadband networks are widely available.

ICM integrated and enhanced the TMN related results of the RACE Programme and other initiatives, so performing an important validation function in the area of TMN. The project established an advanced management capability comprising a platform, management applications and network interfaces, which has been successfully applied to the management of real IBC networks. ICM gained and demonstrated valuable experience in the development of IBC management systems, which forms a firm foundation for the development of future standards, products, and further advanced research.