

AGEDIS: Automated Generation and Execution of Test Suites for Distributed Component-based Software

Press Release

Project Summary

In the last week of October, the European Commission signed an agreement to fund a three-year research project on the automation of software testing. The consortium that will carry out the research and development work consists of seven industrial and academic research centres in Europe and the Middle East. The consortium is headed by the IBM Research Laboratory in Haifa, and contains academic partners at the Oxford University Computing Laboratory, the Verimag laboratory at Universite Joseph Fournier in Grenoble. The major industrial partners are France Telecom R&D, the IBM development Laboratory in Hursley Park (UK), and Intrasoft International, a major software development company with headquarters in Luxembourg and Athens. The company charged with developing commercial applications of the project is a small dynamic software testing company, imbus GmbH, based in Moehrendorf Germany.

The aim of the project is to increase the efficiency and competitiveness of the European software industry by automating of software testing, and improving the quality of software while reducing the expense of the testing phase. AGEDIS will achieve this by developing a methodology and tools for the automation of software testing in general, with emphasis on distributed component-based software systems.

The total budget of the project is 4.3 Million EURO, of which the EC is funding 2.3 Million EURO. The IBM Israel Haifa Research Laboratory will coordinate and manage the project.

Project Objectives

Software is becoming increasingly complex, and the testing of software is taking up a greater proportion of development budgets. Testing was reported as 32% of development effort in Verbruggen's article on Controlling Development and Maintenance Costs in Telecom Systems (*Proceedings of the Telecom Open Seminar: Strategies and Solutions for an Open Telecom World*, 1993). Maintenance costs are also rising and these costs are directly related to the quality of the software, although it is difficult to measure the direct effects of better testing on maintenance costs. For these reasons, it is of critical importance for the software industry to develop efficient automated methods to achieve higher product quality at lower testing costs.

Current software testing practice is based on a highly manual process for generation of test cases based on requirements or specifications documents. These manually generated tests are sometimes executed using an ad hoc execution framework —

typically constructed as a test driver for the particular application under test. These processes are often tedious and error prone, and fail to provide the required level of quality. The goal of AGEDIS is to address these problems by providing a methodology and toolset for automation of testing to give improved software quality at a lower cost.

One fundamental problem in the current software development environment is that testing is not begun at early enough in the development process. AGEDIS recommends a methodology that begins as soon as the software functional specification is available. This enables the "testware" to be developed in parallel with the software and facilitates defect detection even before code is written. This early defect discovery occurs as the specification is exposed to early scrutiny. Moreover defects detected at an early stage of the development are much cheaper to fix (see Software Testing Techniques, Boris Beizer).

The major piece of testware produced by a test organization in the AGEDIS methodology is not a suite of test cases. Rather, it is a **model of the software application** written in a software modelling language, specifically designed to enable the automated generation of a comprehensive test suite.

The other fundamental piece of testware produced is a set of **test case objects** that bridge the gap between the model and the implementation. This enables the test execution engine to execute the test suite and compare the results of the test execution with the predictions of the model.

AGEDIS will develop state-of-the-art technology to automatically generate a test suite based on coverage criteria and testing constraints defined in the model. A component-based execution engine that encapsulates knowledge of the model then executes the automated test suite and its translation to the software under test. This approach is particularly suited to component-based software whose interfaces are clearly specified.

AGEDIS intends to capitalize on the experience and expertise of the research partners in this field, while providing an industry-proven methodology and automation tools for the use of the European Community's Software Development Industry.

By the end of the project, AGEDIS will have proven its effectiveness as a methodology and toolset. This will be done by comparative studies with existing testing methodologies and with existing tools that implement similar methodologies.

As part of the tangible objectives of the project, we intend to have the AGEDIS methodology and tools adopted by at least four leading software producers in the European community.

The results of the project will be available to all European software producers, both in the form of an educational package and software tools, and as a testing service provided by the technology transfer member of the consortium.

Consortium Partners

Name	Contact Person	Country
IBM Israel Science and Technology Ltd.	Alan Hartman	Israel

(Haifa Research Laboratory)		
Intrasoft SA	Antonis Ramfos	Luxembourg
imbus GbmH	Klaudia Dussa-Zieger	Germany
Verimag (Universite Joseph Fournier)	Yassine Lakhnech	France
Oxford University Software Engineering Centre	Jim Woodcock	UK
France Telecom R&D	Yves-Marie Quemener	France
IBM Hursley Development Laboratory - MQ Series	Ian Craggs	UK

Participant Roles

Organization	Roles
IBM Haifa Research Laboratory	<ul style="list-style-type: none"> • Coordinator • Technology supplier • Tool architect
Intrasoft International	<ul style="list-style-type: none"> • Tool user • Tool integrator • Technology supplier
imbus GbmH	<ul style="list-style-type: none"> • Tool user • Testing expertise • Technology transfer
Universite Joseph Fournier	<ul style="list-style-type: none"> • Technology supplier
Oxford University Software Engineering Centre	<ul style="list-style-type: none"> • Language expertise • Educational expertise
France Telecom R&D	<ul style="list-style-type: none"> • Tool user
IBM Hursley Laboratory – MQ Series	<ul style="list-style-type: none"> • Tool user

Innovative Aspects of the Project

AGEDIS will advance the state of the art in software testing, moving the industry towards greater automation of the testing process and higher quality software through the introduction of:

- **Software modelling for automatic test generation, execution, and verification.** The use of model driven test generation is in its infancy and there are no existing tools that integrate test generation with execution and verification.
- **Implementing a test case as a software component (JavaBean).** This is a novel way to improve the maintenance of test suites and facilitate the incremental development of re-usable testware.
- **Integration between test generation and test execution in a distributed and non-deterministic environment.** No currently available tools are able to deal, in an efficient manner, with test execution in a dynamic, non-deterministic distributed environment. All available automation technologies assume the total predictability of the unit under test in order to verify that a test case has completed successfully.
- **Feedback from test execution to further test generation.** The use of coverage analysis and error analysis to enhance the quality of a test suite is a well-documented technique, but there are no tools to automate the process. Moreover, the use of coverage feedback is more of a theoretical rather than an accepted testing practice. AGEDIS will provide a fully automated feedback path from test execution results to test generation engine – thus enabling this testing practice to be used in practical situations with more efficiency.
- **Use of exhaustive model traversal and partial search techniques for test generation.** Exhaustive model traversal is only an option if the number of states is not too large. There are numerous heuristics for partial search of a finite state machine, and various techniques to guarantee their effectiveness. AGEDIS will research the most effective test generation heuristics in the area of distributed software models. There are likely to be specific techniques for distributed software that are more appropriate than the generic techniques appearing in research publications. The consortium will also pioneer new techniques in this area based on the previous research and technological expertise of the partners.
- **Visual reporting of test results using a test suite browser.** Visual presentation of data is a proven technique for improved productivity. Commercially available testing tools do not provide visualization of test suites as a whole in conjunction with their coverage statistics.
- **An open architecture** that supports standardized and public data exchange specifications between all major components, to encourage broad acceptance and exploitation of the tool set by the general testing community and test tool developers.

General Description

The project consists of three parallel action streams: technology development, application experiments, and technology transfer. The activities within these streams take place in three phases: requirements gathering and definition, prototyping, and production.

In the first phase of AGEDIS, we will study existing software modelling languages — both graphical and textual (e.g. SDL, Murphi, UML, Lotos, SPIN, Z, CSP) — and define a language for modelling with all the requisite constructs for high level modelling of component-based distributed software for the purpose of generating test suites. The language will be chosen with regard to achieving wide acceptability and rapid adoption in European software development centres. Thus the likely course of action will be the choice of an existing language and the definition of extensions to the language to facilitate test generation and coverage analysis.

The second element of the first phase involves two application experiments to be carried out with existing prototype tools provided by the consortium partners. The purpose of these experiments is to evaluate and refine the requirements for the modelling and integrated toolkit. These initial studies will take 4–6 months and include a retest of an existing function in a product (to provide a baseline for measuring success) and a pilot study of a new feature being added to a product.

The second phase involves intensive research and development of a software modelling language, its compiler, and the integration of the tools into a unified test automation environment. This phase will be driven by the requirements generated during the application experiments.

This phase will be punctuated by three application experiments: one with the first version of the unified toolkit and methodology, and two with the final products of the project. The consortium partners will do additional informal application experiments using the AGEDIS tools and methodology to test certain components of the AGEDIS software tools themselves.

The third and final phase of AGEDIS will include the publication of a methodology document, and the final production of test generation and execution tools integrated and improved on the basis of feedback from the second round of application experiments. The project will close with a public seminar including a tutorial on the use of the tools and papers describing the application experiments and their results.

Company Profiles

IBM Haifa Research Laboratory

Organization profile

The IBM Haifa Research Laboratory (HRL) is a subsidiary of IBM Israel. The main mission of HRL is to perform research that advances IBM's products and product development capabilities. HRL reports into the IBM Corporation's Research Division and has close working relationships with IBM Israel and its twin research laboratory in Zurich. HRL's Formal Methods Group has experience in model-checking; this group is a part of the Verification Technologies Department headed by Yossi Malka.

The Verification Technologies department is a key participant, a leader, and a recognized centre of competence in all verification activities of the IBM corporation worldwide. Over the past 17 years, there has been a steady dissemination of information, tools, and methodologies from HRL (formerly IBM Science and Technology) to the corporation's European centres, including Essones France and the large design centre in Boeblingen, Germany. The department has marketed its tools to external customers, including a number of design companies in Israel and ST Microelectronics in France, the UK, and Italy.

The department is currently engaged in two framework projects, Genevieve (design verification) under the 4th Framework and Odette (high level modelling) under the 5th Framework.

The Formal Methods Group is well known both inside and outside IBM as the developer of RuleBase, the IBM proprietary world-class model checker. RuleBase is used in virtually all IBM processor projects as well as in ASIC groups inside and outside IBM, and has been licensed to other companies (e.g., ST Microelectronics and Zoran Microelectronics). RuleBase was recently mentioned in the announcement of the ACM Kannelakis Award given to prominent computer scientists E. Clarke, K. McMillan, R. Bryant, and A. Emerson. RuleBase was mentioned as a tool where advanced testing technologies have been implemented and successfully put to practical use.

HRL's Systems Applications Group is engaged in developing software systems with a high technological content including call centre control systems, customer access applications, and mathematical optimisation of scheduling systems. In developing these systems, the group has been extensively involved in testing a wide range of products and in supplying IBM internal tools for software testing. The Formal Methods Group and the Systems Applications Group jointly developed an automated software testing system known as GOTCHA-TCBeans.

Key personnel

Dr. Alan Hartman holds a Ph.D. in mathematics from the University of Newcastle, in Australia, an M.Sc. in mathematics from the Technion Israel Institute of Technology, and a B.Sc. (Hons) in mathematics from Monash University in Australia. He joined IBM Haifa Research Laboratory in 1983 after a postdoctoral fellowship at the

University of Waterloo in Canada. He has spent two periods on leave at the University of Toronto, and at Telstra Research Laboratories. His career at IBM has included research in Storage Technologies, Communications Network Design, Mathematical Optimisation, and most recently, Hardware Verification. Hartman is interested in applying hardware testing technologies to the software-testing domain, and is currently working on the GOTCHA-TCBeans project and its deployment within IBM. Hartman has extensive management experience, having managed the Algorithms and Optimisation group at HRL, a unit of 12-15 people, for three years. During this time Hartman managed and coordinated projects with customers and development teams in Europe and the United States.

Kenneth Nagin was educated in the USA, receiving his B.A. from the University of Madison and B.S. from the University of Pittsburgh. He joined the IBM Haifa Research Laboratory in 1985 and has worked on various subjects including, copy services and disaster recovery solutions for direct access storage devices and test tool development. He manages the testing for HRL's Systems Application projects including, IP over CATV, voice over IP, and Kiosk solutions for digital libraries. He holds seven patents. Currently, he is conducting functional testing on IBM's Host On Demand software application using the GOTCHA-TCBeans test tools developed by HRL. His current research is concerned with automatic software testing and quality control in software development.

Currently, Hartman and Nagin are conducting function tests on IBM's Host On Demand software application, Universal Contact Manager, and CS390 Sysplex using the GOTCHA-TCBeans test tools, which are being prototyped by HRL.

Intrasoft International

Organization profile

INTRASOFT International S.A. is an innovative, dynamic IT Service Provision company, providing services in the fields of *Systems Development and Integration*, *Systems Management* and *Managed Services*. The company's multidisciplinary team of high calibre software engineers, field experts, as well as its strategic relationships, provide customised solutions to a number of industry sectors that include Telecommunications, Finance and Banking, Public Administration and Government. INTRASOFT International operations are located in Brussels, Luxembourg and Athens; they also deliver services in Germany, Italy, Spain and Ireland.

INTRASOFT International has evolved from the Western European Division of INTRASOFT S.A., the leading Software Development and Systems Integration Company in Greece. They are also the most recent offspring of the INTRACOM Group, the primary IT and Telecommunications group in Greece, which employs 3,500 people worldwide with a consolidated annual turnover of 440 million Euro (470 million USD). Although INTRASOFT International was formally incorporated in Luxembourg in 1996, its management and key personnel have been active in this market since 1992, setting-up the foundations for an innovative new company. The smooth transition of INTRASOFT's technical infrastructure, human resources and experience has guided INTRASOFT International S.A. into becoming a leading Systems Integrator/Software Development company in the European Union with valuable market leads in Eastern Europe and the Mediterranean countries.

INTRASOFT International currently supports the IT needs of more than 30,000 users in Western Europe, with a turnover in 1998, of 13.65 million Euro (14.93 million USD) with some 1.7 million Euro (1.88 million USD) in profit.

INTRASOFT International's activities are provided within in the following three distinct disciplines:

Software Development & Systems Integration activities primarily centre on mission-critical distributed Intranet/Internet based information management applications. INTRASOFT International has been awarded the development and delivery of some of the most recognised and critical applications in Europe. Representative projects include: **European Central Bank** – Systems for Conducting Monetary Policy by the European Central Bank and the Central Banks of the Euro zone countries; **MCI WorldCom** - Telecom billing system and data warehousing; **DGXXI/Transit Computerisation Project** - Computerisation of 15 EU, EFTA and V4 countries Custom Offices for Transit Goods; **European Parliament** - development and maintenance of all mainstream information systems; **DGXXIII / Euro Info Centres Central Office** - Application Development and User Support for 300 EICs around Europe and the World; **DG XXIII / Business Co-operation Network** - Application Development and User Support for 2000 business consultants around Europe and the world.

Systems and Network Management activities support more than 20,000 users in Brussels, Luxembourg and Strasbourg on a daily basis, covering LAN and WAN services, comprehensive PC support and EDP management. Representative services provided under Systems and Networks Management include: **INSEM 3** - Design, migration, deployment and operation of the new European Commission's e-mail system, affecting over 20,000 users and all its sites; **DI-SURE** - 1st and 2nd level Help-Desk and Support for all European Commission's Data Networks that include over 20,000 users in over 70 buildings in Brussels, Luxembourg and Strasbourg; **USSA-VI** - Users Support and Systems Administration for PC and Servers with over 1,100 users in Brussels, for DGVI of the European Commission; **USSA-1B** - Users Support and Systems Administration for PC and Servers for over 300 users in Brussels, for DG1B of the European Commission.

Managed Services go beyond the traditional model of Information Systems outsourcing, by providing an integrated service incorporating also non-IT business functions. This is the case with an information dissemination service, whereby, apart from the IT component, other functions such as information collection, service operation, web design, help-desk/call-centre, marketing and training, are parts of the solution. As a direct consequence, INTRASOFT International has significant project management experience in delivering highly complex multinational, multidisciplinary services. Representative Managed Services projects include the following: **CORDIS** - EU's Premium Information Collection and Dissemination Service for all European R&D activities; **PROSOMA** - Technology Transfer Showcase and Brokerage Service; **INFO2000** - EU's information dissemination and central support service for the development of the European multimedia content industry.

In order to keep abreast of technological developments, INTRASOFT International undertakes extensive R&D activities that constitute the strategic continuation of INTRASOFT's long record of participation in international consortia. Through this

participation, INTRASOFT International acquires leading edge technologies while forging new business relationships and partnerships with other companies and international institutions. Indicative international R&D projects that INTRASOFT International currently participates in include the following: **Ca\$hman (ACTS)** - Pricing schemas in ATM networks; **NOTE (ESPRIT)** - Software platform for mobile workstations; **CATSERVER (ESPRIT)** - Video on-demand services; **MODEL (IST)** – Enterprise Knowledge Management and Training System; **LIMBER (IST)** – Searching Tools for Multilingual Information Systems; **C-CARE (IST)** Data Warehousing for Medical Information.

Key personnel

Dr. Antonis Ramfos joined INTRASOFT in 1993 and is currently the Head of the R&D Section of INTRASOFT. Ramfos has gained considerable experience in managing R&D projects, and the R&D section has participated in several projects within the frameworks of ESPRIT, TELEMATICS, ACTS, TEN-ISDN, and IMPACT programmes. His current research interests include Quality Software Engineering, Content Management/Dissemination Systems and Tools, Internet-based Technologies, and Information Provision Systems. Ramfos, up to April 1997, held the position of Senior Consultant at INTRASOFT in the area of centralized and distributed database systems. Ramfos, up to January 1996, held the position of Contract and Account Manager in INTRASOFT's Marketing Division of Western Europe, and he has managed several R&D projects including, ESPRIT/REALISE, ESPRIT/IRO-DB, ESPRIT/FAPSY, TEN-ISDN/PROTONET, IMPACT/PROMONET, TELEMATICS/AQUARELLE, to mention but a few. Ramfos, up to December 1995, held the position of Project Leader in various commercial IT projects. Finally, from June 1986 to December 1990, he held the position of Tutorial and Research Fellow in the Department of Computer Science at University of Wales, College of Cardiff, UK.

Dr. Nikos Dendris joined INTRASOFT in 1997 and is experienced in leading large IT projects in the company. He has been the Technical Leader of the Transit Computerisation Project (DGXXI), being responsible for development and testing of the communications module that interconnects several components via the CCN network and the TUXEDO architecture, as well as for the validation and translation of messages between XML and EDIFACT formats. Dendris participated as Senior Software Developer in the European Monetary Institute project, being responsible for syntax analysis of messages, database design and network protocols. Dendris has participated in several R&D projects and has extensive experience in state-of-the-art software engineering technologies and quality assurance. He holds a Ph.D. degree from the University of Patras, Greece.

imbus GmbH

Organization profile

imbus is an up and coming software company which specializes in the fields of quality assurance and software testing. In addition to providing customer-specific consulting services and practice-oriented seminars in these fields, imbus also develops standard products for the software testing process. imbus' customers include software companies, software vendors, and the engineering departments of large manufacturers particularly in the field of medical systems and telecommunications.

imbus is certified per DIN ISO 9001 since 02/1995 and a certified consulting & training partner of the leading test tool manufacturer Mercury Interactive®.

imbus GmbH was established by six partners on January 1, 1992. With continuous growth of 30% p.a. imbus has grown to about 60 employees today. To serve customers and continue achieving a company growth rate of 30%, imbus is committed to applying world-class testing methods and using the leading testing tools on the market. In order to achieve this goal, it is necessary to maintain an active research and development presence in software engineering and software testing. This R&D activity is seen as crucial to maintaining competitive advantage.

imbus has already successfully performed an ESSI PIE project 24306 "Automated Testing of Graphical User Interfaces". As result of this PIE project imbus has learned to automate testing up to rates of 90% during test execution phase (which is the last step within the testing process).

imbus' goal in the AGEDIS project is to learn automation within the early testing phases: test design and test case generation. As result imbus will be able to offer test automation services covering the complete testing process not only to the German but also to the European software industry in the near future.

As an SME imbus would never be able to achieve only one of these goals on its own.

Key personnel

Dr. Klaudia Dussa-Zieger received her Ph.D. in Computer Science in 1998 from the University of Erlangen-Nuremberg, Germany. She holds an M.S. in Computer Science from the University of Maryland at College Park, and a Dipl.Inf. from the University of Erlangen-Nuremberg. She spent a year studying in Maryland on a post-graduate stipend from the DAAD.

Dussa-Zieger joined imbus in 1998. Since then she has been the project leader on several software testing projects. In parallel with her project work she has started a research group within imbus. Her research group is involved in several research activities with the University of Erlangen-Nuremberg, and is currently participating in two EC research proposals.

Matthias Daigl received his Dipl.Inf. in Computer Science in 1995 from the University of Erlangen-Nuremberg. He joined imbus in 1996. As a software engineer in the medical field, he has attained comprehensive knowledge of quality management and software testing. Daigl also developed and holds seminars on automated software testing. As part of the 'ESSI'-Initiative, Daigl was selected to be the Project Test Manager in the PIE-Project "Automated Testing of Graphical User Interfaces".

Verimag – Universite Joseph Fournier

Organization profile

VERIMAG, headed by Dr. J. Sifakis, is an academic laboratory focusing on the theoretical and practical aspects of formal methods for software engineering. VERIMAG has a proven record in both basic theoretical research and in development of tools such as the model-checking toolbox CADP, the test case generator TGV, the data-flow synchronous language Lustre, the Kronos tool for verification of timed

automata and the InVeSt tool for the verification of infinite state systems. VERIMAG has an ongoing interaction with industry including Verilog, CNET, Schneider, and Aerospatiale and with academic partners such as Weizmann, Berkeley, SRI, Uppsala, and Kiel.

Key personnel

Dr. Yassine Lakhnech received his Ph.D. in Computer Science in 1996 from the University of Kiel with a dissertation titled "Specification and Verification of Hybrid and Real-Time Systems". He received his Habilitation in Computer Science and Applied Mathematics in 1998 from the Universite Joseph Fourier, Grenoble. From 1990-1995 he was employed at the University of Kiel. In 1995 he was a visiting researcher at the VERIMAG laboratory in Grenoble. From 1996 -1999 he was a researcher "Wissenschaftlicher Assistent", at the University of Kiel, Germany. Since October 1999 he has been a Professor at the Universite Joseph Fourier in Grenoble and a member of the VERIMAG laboratory. He served as the substitute for Prof. de Roeber in coordinating Task 3 of the BRA EU project REACT and, together with Pierre Wolper, is coordinating the Work package Methodology and Tools of the LTR project no 23498 "VIRES". His main interests include the semantics, specification and verification of reactive and, in particular, infinite state, reactive systems.

Dr. Laurent Mounier is an associate professor at the Universite Joseph Fourier, Grenoble and a member of VERIMAG. He received his Ph.D. in Computer Science in 1992. His research activities include the validation of protocols, the development of model-checking and testing techniques, and the implementation of tools for the validation of protocols. In particular, he contributed to the development of the CADP validation toolbox that has been distributed to more than 220 sites since 1990. He is also working on the SDL specification language and its semantics and contributing to the development of a validation environment linked to the commercial tool ObjectGeode of Verilog.

Oxford University Software Engineering Centre

Organization profile

The Software Engineering Centre is part of the Oxford University Computing Laboratory. The Laboratory is the academic computing department for the University, and is graded by the UK government as 5* in research and Excellent in teaching (both the highest grades). It was founded forty years ago, and has a tradition of combining first-class theoretical work with practical application in industry. It has twice been given the Queen's Award for Technological Achievement: first for its work with Inmos on the transputer, and second for work with IBM on formalising the CICS transaction processing system.

The Laboratory is known for its research in programming techniques, including formal methods for sequential and concurrent systems (Z and CSP), model checking distributed systems (FDR), novel techniques for requirements engineering, critical systems development (analysing safety and security), hardware compilation (Handel-C), and theoretical underpinnings (denotational semantics and the Unifying Theory of Programming).

The Software Engineering Centre was recently nominated as the UK's Centre of Excellence by the government. Its mission is to transfer modern software engineering techniques to industry through a mixture of education, training, research, and consulting. It has connections with over fifty national and international companies.

The Centre is involved in a number of relevant projects. The Linking Tools project, funded by the UK EPSRC, applies Hoare & He's Unifying Theory to combining Z and CSP and linking model-checking and theorem-proving tools. The Smart Card project, funded by a major bank, has recently assured a smart card product up to ITSEC Level E6; the first product ever to achieve this highest level of assurance. The FMERail project, funded by the European Commission, has been applying formal methods to the assurance of railway infrastructure, using a variety of techniques, including model-checking assisted by theorem-proving.

Key personnel

Dr. Jim Woodcock holds a B.Sc. (Hons) degree in Computation, an MSc in Operational Mathematics, and a Ph.D. in Computation, all from the University of Liverpool, and an M.A. from the University of Oxford. He spent four years working for the General Electric Company of England in their Telecommunications Research Laboratory. For the last fifteen years, he has worked at the University of Oxford, where he is the Reader in Software Engineering and Director of the Software Engineering Centre; he leads a team of 16 people. He is known for his research, teaching, and consultancy in software engineering. In 1992, his team won a Queen's Award for Technological Achievement jointly with IBM, and in 1997, they won a Centre of Excellence Award from the UK government. He has been a Visiting Professor in Beijing, Dublin, Hiroshima, Klagenfurt, Kyushu, and Tulane.

France Telecom R&D

Organization profile

France Telecom R&D, currently employs 4200 people including 3400 engineers, scientists, and technicians and 150 scientists or doctoral candidates from other organisations. Its annual budget amounts to 3 billion francs. The activities of France Telecom R&D are distributed among 7 R&D Directions focused on the company's major strategic targets and critical technical areas.

The tremendous impact of telecommunications on economic development has intensified efforts at the European level to promote R&D in this sector. France Telecom R&D is thus working with numerous partners including universities and manufacturers from all over Europe on over 100 co-operative research projects.

In the present project, France Telecom R&D will be represented by the Direction of Software Techniques: DTL. The team involved in the project deals both with improvements of formal languages for protocol specification (like SDL), and with verification techniques, including automatic generation of test suites.

Key personnel

Dr. Yves-Marie Quemener graduated from the École Nationale Supérieure des Télécommunications de Bretagne in 1992. In 1996, he received a PhD from the

Université de Rennes I. The subject of his thesis was the validation of protocols with infinite reachability set, using a representation of the reachability graph with a graph grammar. Since 1997, he has been working at France Telecom R&D. His current research is focused on the automatic generation of test suites.

Mikael Marche began a Ph. D. Thesis at the "Université de Franche-Comté" in 1999. He holds a Post Graduate degree from the "Université de Franche-Comté". The subject of this work was the generation of test cases for formal B specifications. He continues his Ph. D. work at France Telecom R&D on the automatic generation of test suites for distributed programs using mobile code.

IBM UK Laboratories

Organization profile

The IBM laboratory at Hursley Park near Winchester in England was started in 1958 for both software and hardware development, with involvement in projects such as System/360, displays, disk systems, and PL/I. In the 1980s, it became purely software oriented, and since 1974 has been the home of CICS, which is used by 470 of the Fortune 500 companies and processes 20 billion transactions a day worldwide. The CICS product was restructured in the 1980s in a project partnered with Oxford University using the formal notation Z.

Since 1992, the laboratory has developed the MQSeries family of products, which provide an open, scalable, industrial-strength messaging and information infrastructure, enabling enterprises and beyond to integrate business processes. MQSeries is now the middleware market leader.

Key personnel

Since graduating from Cambridge University in 1983 with a B.A. in Engineering/Computer Science, Ian Craggs has spent most of his working life in IBM testing software. From 1983 to 1989 he tested CICS, a product on which many large companies rely and as a consequence has to be thoroughly tested for reliability. He received an IBM Outstanding Innovation Award in 1988 for improving the way the testing was accomplished. Since 1992 he has worked on MQSeries, a very successful asynchronous messaging product which also has high claims for reliability and for which comprehensive testing is needed. He received an M.Sc. in Software Engineering from Oxford University in 1998 after following a course in which formal methods are the main focus, and his dissertation employed both Z and CSP. Craggs' interests lie in improving the efficiency of software testing by the application of rigorous techniques.

