

Programme Area: IST FET

Date of filling: 28/04/2005

Project Acronym: CORTEX

Questions about project's outcomes	Number	Comments
1. Scientific and technological achievements of the project (and why are they so ?)		
<p><u>Question 1.1.</u></p> <p>Breakthrough or "real" innovation</p>		<ol style="list-style-type: none"> 1. Timely Computing Base (TCB) software for Microsoft Windows CE 3.0. The TCB is a distributed embedded component that provides a set of time related services to client applications. 2. An extension of the TCB for RTAI to support mobile computing applications (e.g. wireless communications). 3. A Generic-Events ARchitecture (GEAR) that supports event-based object-oriented programming on real-time cooperative and embedded systems. It is the first architecture to provide hidden channel avoidance in the model, that is, a seamless integration of physical and computer information flows. 4. A new technique to measure distributed durations that minimizes the measurement error and is able to keep this error almost stable – we called it Improved Round-Trip Technique (IMP). With this technique it is possible to achieve a lower reading error of remote clocks than with the well known round-trip duration measurement technique proposed by Cristian. 5. A cooperating cars software prototype for Microsoft Windows CE 3.0. This prototype simulates the behaviour of autonomous cars communicating and cooperating with other cars in its proximity. The communication is done through IEEE 802.11b (WiFi) and the required timeliness is guaranteed by the TCB software developed for Microsoft Windows CE 3.0. 6. A middleware event service (Adaptable Timed Event Service - ATEs) that extends the CORTEX publishing/subscribing programming model with constructors to deal with timeliness requirements. ATEs hides from sentient objects the low level services provided by the TCB, concerning to timing failure detections, coverage stability and awareness, and timely executions, providing high level abstractions suitable for timeliness issues. 7. A software platform for the emulation of real environments, which can be used to develop and test CORTEX applications. This software allows to test subtle coordination and synchronization phenomena, difficult to reproduce and/or follow in real-life systems. 8. A scalable timed event model for mobile, ad hoc environments (STEAM). The event model is completely distributed, not relying on the presence of any separate infrastructure, and allows event filtering on subject, content, and geographical proximity.

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		<p>8a. Event based middleware architecture for ad hoc networks.</p> <p>8b. A filter engine for functional and non-functional event notification for mobile applications.</p> <p>9. A new MAC protocol for wireless ad hoc networks (TBMAC) based on time-division multiple access with dynamic, but predictable slot allocation. This is the first time-bounded MAC protocol for multi-hop wireless ad-hoc networks.</p> <p>9a. A simulation of TBMAC using the NS2 simulator.</p> <p>9b. A real-world implementation of TBMAC using IEEE 802.11.</p> <p>10. A model for the development of mobile, context-aware applications based on sentient objects. The sentient object model defines software abstractions to ease the development of applications, addressing the major requirements of the development of such applications.</p> <p>11. A high-level, graphical programming tool implementing the sentient object model and providing end-user support for the development of mobile, context-aware applications based on sentient object model.</p> <p>12. Low-level real-time device drivers to provide real-time guarantees within the Linux network subsystem.</p> <p>13. An analysis and evaluation of reliable link quality prediction in a real-world, urban environment.</p> <p>14. A proximity-based service-discovery mechanism that exploits the fact that the relevance of ad hoc services is often limited to specific geographical scopes.</p> <p>15. Federated Event Service.</p> <p>16. Reflective and Component framework based Middleware platform for Sentient Object based Applications.</p> <p>17. The cooperating sentient vehicle CORTEX demonstrator.</p> <p>18. OpenCOM v1 component technology for Small devices (i.e., PDA).</p> <p>19. COSMIC event-based middleware for substantially constraint networked micro controllers. COSMIC provides a fairly high programming interface for applications and supports automatic network configuration, dynamic interaction and interoperability between multiple physical networks.</p>
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2. Impact on Science and Technology: Scientific Publications in scientific magazines

Question 2.1.

"Standard" scientific or technical publications
(from one partner's lab)

A. Casimiro and M. Correia, "**Recent Advances on the Timely Computing Base Model**", Fast Abstract at the International Conference on Dependable Systems and Networks, Göteborg, Sweden, June 2001.

A. Casimiro and P. Verissimo, "**Using the Timely Computing Base for Dependable QoS Adaptation**", Proceedings of the 20th IEEE Symposium on Reliable Distributed Systems, New Orleans, USA, October 2001.

A. Casimiro, P. Martins, P. Verissimo, and L. Rodrigues, "**Measuring Distributed Durations with Stable Errors**", Proceedings of the 22nd IEEE Real-Time Systems Symposium, London, UK, December 2001.

A. Casimiro and P. Verissimo, "**Generic Timing Fault Tolerance using a Timely Computing Base**", in Proceedings of the 2002 International Conference on Dependable Systems and Networks, Washington D.C., USA, June 2002.

P. Verissimo and A. Casimiro, "**The Timely Computing Base Model and Architecture**", IEEE Transactions on Computers - Special Section on Asynchronous Real-Time Systems, vol. 51, n. 8, Aug 2002.

P. Sousa and P. Verissimo, "**Towards a cooperating autonomous car**", in Proceedings of the 7th CaberNet Radicals Workshop, Bertinoro, Italy, Oct 2002.

P. Martins and P. Verissimo, "**The Timely Computing Base and its Future Trends**", in Proceedings of the 7th CaberNet Radicals Workshop, Bertinoro, Italy, Oct 2002.

N. Reijers, R. Cunningham, R. Meier, B. Hughes, G. Gaertner, and V. Cahill, "**Using Group Communication to Support Mobile Augmented Reality Applications**," in Proceedings of the 5th IEEE International Symposium on Object-oriented Real-time distributed Computing (ISORC 2002). Washington DC, USA, 2002.

R. Meier and V. Cahill, "**STEAM: Event-Based Middleware for Wireless Ad Hoc Networks**," in Proceedings of the International Workshop on Distributed Event-Based Systems (ICDCS/DEBS'02). Vienna, Austria, 2002.

R. Meier and V. Cahill, "**Taxonomy of Distributed Event-Based Programming Systems**," in Proceedings of the International Workshop on Distributed Event-Based Systems (ICDCS/DEBS'02). Vienna, Austria, 2002.

R. Cunningham and V. Cahill, "**Time Bounded Medium Access Control for Ad Hoc Networks**", in Proceedings of the Second ACM International Workshop on Principles of Mobile Computing (POMC'02). Toulouse, France: ACM Press, 2002, pp. 1-8.

A. Fitzpatrick, G. Biegel, S. Clarke, and V. Cahill, "**Towards a Sentient Object Model**", presented at Workshop on Engineering Context-Aware Object Oriented Systems and Environments (OOPSLA/ECOOSE'02), Seattle, Washington, USA, 2002.

P. Verissimo and A. Casimiro, "**Event-Driven Support of Real-**

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	<p>Time Sentient Objects", in Proceedings of the 8th IEEE International Workshop on Object-oriented Real-time Dependable Systems, Guadalajara, Mexico, January 2003.</p> <p><i>B. Hughes and V. Cahill</i>, "Towards Real-time Event-based Communication in Mobile Ad Hoc Wireless Networks" in Proceedings of 2nd International Workshop on Real-Time LANS in the Internet Age 2003 (ECRTS/RTLIA03), Porto, Portugal, July 2003, pp. 77-80.</p> <p><i>R. Meier and V. Cahill</i>, "Exploiting Proximity in Event-Based Middleware for Collaborative Mobile Applications", in Proceedings of the 4th IFIP International Conference on Distributed Applications and Interoperable Systems (DAIS'03), LNCS 2893. Paris, France: Springer-Verlag, 2003, pp. 285-296.</p> <p><i>B. Hughes and V. Cahill</i>, "Achieving Real-time Guarantees in Mobile Ad Hoc Wireless Networks", Work in progress session, IEEE Real Time Systems Symposium, Cancun, Mexico, December, 2003.</p> <p><i>P. Martins, P. Sousa, A. Casimiro, and P. Verissimo</i>, "Dependable Adaptive Real-Time Applications in Wormhole-based Systems". In Proceedings of the International Conference of Dependable Systems and Networks (ICDSN04), Florence, Italy, June 2004.</p> <p><i>P. Martins, A. Casimiro, and P. Verissimo</i>, "A Generic Temporal Consistency Model for Distributed Control Systems", Workshop on Architectures for Cooperative Embedded Real-Time Systems (WACERTS'04), in conjunction with the 25th IEEE International Real-Time Systems Symposium (RTSS04), December 5-8, 2004, Lisbon, Portugal.</p> <p><i>G. Gaertner and V. Cahill</i>, "Understanding Link Quality in 802.11 Mobile Ad Hoc Networks", IEEE Internet Computing, Volume 8 (Number 1), 2004, pp 55-60.</p> <p><i>G. Biegel and V. Cahill</i>, "A Framework for Developing Mobile, Context-aware Applications", in Proceedings of 2nd IEEE Conference on Pervasive Computing and Communications, (Percom) 2004, Orlando, FL, March 14-17, 2004.</p> <p><i>C. Ryan, R. Meier, and V. Cahill</i>, "Federating Heterogeneous Event Services", in Proceedings of the Third International Workshop on Distributed Event-Based Systems (DEBS'04), Edinburgh, United Kingdom, May, 2004, pp 86-91.</p> <p><i>G. Gaertner, E. ONuallain, A. Butterly, K. Singh, and V. Cahill</i>, "802.11 Link Quality and its Prediction - An Experimental Study", in Proceedings of the IFIP TC6 9th International Conference on Personal Wireless Communications (PWC 2004), Delft, The Netherlands, September, 2004, pp 147-163.</p> <p><i>B. Hughes, R. Meier, R. Cunningham, and V. Cahill</i>, "Towards Real-Time Middleware for Vehicular Ad Hoc Networks", in Proceedings of the First ACM International Workshop on Vehicular Ad Hoc Networks (VANET 2004), Philadelphia, USA, October, 2004, pp 95-96.</p>
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	<p><i>H. Duran-Limon, G. Blair, "QoS Management Specification Support for Multimedia Middleware", The Journal of Systems and Software 72(1), pp 1-23: 2004.</i></p> <p><i>J. Kaiser and E. Nett, "Resolving the Trade-Offs in Designing QoS Communication Services for Control Applications on CAN", Workshop on Architectures for Cooperative Embedded Real-Time Systems (WACERTS'04), in conjunction with the 25th IEEE International Real-Time Systems Symposium (RTSS04), December 5-8, 2004, Lisbon, Portugal.</i></p> <p><i>J. Kaiser, "Event Channels, an Integration Concept for Predictable Interaction in Embedded Heterogeneous Networks", International Workshop on Dependable Embedded Systems, October 17, 2004, in conjunction with the 23rd Symposium on Reliable Distributed Systems (SRDS 2004), Florianopolis, Brazil.</i></p> <p><i>J. Kaiser, C. Brudna, and C. Mitidieri, "Implementing Real-Time Event Channels on CAN-Bus", 5th IEEE International Workshop on Factory Communication Systems, Vienna, Austria, September 22nd-24th, 2004.</i></p> <p><i>C. Mitidieri, J. Kaiser and C.E. Pereira, "An event filtering scheme for distributed real-time embedded systems", Proc. of the 11th IFAC Symposium on Information Control Problems in Manufacturing (INCOM'04). Salvador, Brazil. April, 2004.</i></p> <p><i>J. Kaiser, "An Event Model for the Predictable Interaction of Smart Devices", Workshop on Dependable Embedded Systems, in conjunction with the IEEE 22nd International Symposium on Reliable Distributed Systems, Florence Italy, October 6-8, 2003</i></p> <p><i>J. Kaiser, C. Liu, "Content and Cell based Predictive Routing (CCPR) protocol for Mobile ad hoc networks", 5th International Workshop for Advanced Parallel Processing Technologies (APPT'03), Xiamen, China, Sept. 2003. Lecture Notes in Computer Science 2834: Advanced Parallel Processing Technologies, Springer, pp. 488-495</i></p> <p><i>J. Kaiser, C. Mitidieri, C. Bruna, C.E. Pereira, "COSMIC: A middleware for event-based interaction on CAN", ETFA, Emerging Technologies and Factory Automation, Lisbon, Portugal, September 2003</i></p> <p><i>C. Mitidieri, J. Kaiser, "Attribute based filtering for embedded systems", 2nd International Workshop on Distributed Event-Based Systems (DEBS'03), San Diego, California, June 2003</i></p> <p><i>J. Kaiser, C. Brudna, and C. Mitidieri, "A Real-Time Event Channel Model for the CAN-Bus," Workshop on Parallel and Distributed Real-Time Systems, held in conjunction with the International Parallel and Distributed Processing Symposium IPDPS, 2003, April 22-26, 2003 in Nice, France.</i></p> <p><i>J. Kaiser and T. Fries, "ROCON – A Virtual Construction Kit, Visualization Tool and Remote Control System for Mechatronic Devices," IEEE International Conference on Mechatronics and Machine Vision in Practice 2002, Chiang Mai, Thailand, September 10-12, 2002.</i></p>
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		<p><i>J. Kaiser and C. Brudna, "A Publisher/Subscriber Architecture Supporting Interoperability of the CAN-Bus and the Internet", 2002 IEEE Int. Workshop on Factory Communication Systems, Västerås, Sweden, August 28-30, 2002.</i></p> <p><i>N. Gura, A. Held, J. Kaiser, "Proactive Services in a Distributed Traffic Telematics Application", Informatik 2001: Joint Annual Conference of the GI/OCG, Workshop on Mobile Communication over Wireless LAN: Research and Application, Sept. 25-28, 2001.</i></p> <p><i>J. Kaiser, P. Schaeffer, "ICU – A smart optical sensor for direct robot control", IEEE International Conference on Mechatronics and Machine Vision in Practice 2001, Hong Kong, China, August 27-29, 2001.</i></p> <p><i>C.E.Pereira, L.B. Becker, C. Villela, C. Mitidieri, J. Kaiser, "On Evaluating Interaction and Communication Schemes for Automation Applications based on Real-Time Distributed Objects", ISORC 2001: IEEE 4th International Symposium on Object-Oriented Real-time distributed Computing, Magdeburg, Germany, May 2001.</i></p>
<p><u>Question 2.2.</u></p> <p>"Collaborative" scientific or technical publications, (i.e. involving co-authorship of different partners or different projects)</p>		<p><i>G. Blair, G. Coulson, A. Andersen, L. Blair, M. Clarke, F. Costa, H. Duran-Limon, T. Fitzpatrick, L. Johnston, R. Moreira, N. Parlavantzas, K. Saikoski, "The Design and Implementation of OpenORB v2", IEEE DS Online, Special Issue on Reflective Middleware, Vol. 2, No. 6, 2001.</i></p> <p><i>P. Verissimo, V. Cahill, A. Casimiro, K. Cheverst, A. Friday, and J. Kaiser, "CORTEX: Towards Supporting Autonomous and Cooperating Sentient Entities", Proceedings of European Wireless 2002, Florence, Italy, February 2002.</i></p> <p><i>L. Capra, G. Blair, C. Mascolo, W. Emmerich, and P. Grace, "Exploiting Reflection in Mobile Computing Middleware", ACM SIGMOBILE Mobile Computing and Communications Review, Vol. 6, No. 4, pp 34-44, October 2002.</i></p> <p><i>G. Coulson, G. Blair, M. Clarke, and N. Parlavantzas, "The Design of a Highly Configurable and Reconfigurable Middleware Platform", ACM/ Springer Distributed Computing Journal, Vol. 15, No. 2, pp 109-126, April 2002.</i></p> <p><i>F. Kon, F. Costa, G. Blair and R. Campbell, "The Case for Reflective Middleware: Building Middleware that is Flexible, Reconfigurable, and yet simple to Use", CACM, Vol. 45, No. 6, pp 33-38, 2002.</i></p> <p><i>P. Verissimo, J. Kaiser, and A. Casimiro, "An architecture to support interaction via generic events", Work-in-Progress session, IEEE Real-Time Systems Symposium. Cancun, Mexico, December 2003.</i></p> <p><i>A. Casimiro, J. Kaiser, and P. Verissimo, "An Architectural Framework and a Middleware for Cooperating Smart Components", Proc. Of the 2004 Computer Frontiers Conference, Ischia, Italy, April 14-16, 2004.</i></p>

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		<p><i>R. Meier, J. Kaiser, B. Hughes, and V. Cahill, "An Event Model for Real-Time Systems in Mobile Environments", in Proceedings of the Second IEEE Workshop on Software Technologies for Future Embedded and Ubiquitous Systems (ISORC/WSTFEUS '04). Vienna, Austria: IEEE Computer Society, May 2004, pp. 29-34.</i></p> <p><i>G. Blair, A. Campbell, and D. Schmidt, "Middleware Technologies for Future Communication Networks", IEEE Network, Vol. 18, No. 1, January 2004.</i></p> <p><i>G. Coulson, G. Blair, N. Parlavantzas, W. Yeung, and W. Cai, "Applying the Reflective Middleware Approach in Grid Computing", Concurrency and Computation: Practice and Experience, Vol 16, No 5, pp 433-440, 25 April 2004.</i></p> <p><i>P. Grace, G. Blair, and S. Samuel, "A Reflective Framework for Discovery and Interaction in Heterogeneous Mobile Environments", ACM SIGMOBILE Mobile Computing and Communications Review, 9(1), pp 2-14, special section on Discovery and Interaction of Mobile Services, January 2005.</i></p>
<p><u>Question 2.3.</u></p> <p>Review papers published (specify if one partner or "collaborative" between partners)</p>		<p><i>H. Duran-Limon, G. Blair, and G. Coulson, "A Survey of Adaptive Resource Management in Middleware", IEEE Distributed Systems Online Journal, 2004. (one partner)</i></p> <p><i>Jörg Kaiser, C. Brudna and C. Mitidieri, "COSMIC: A real-time event-based middleware for the CAN-bus", Journal of Systems and Software, Volume 77, Issue 1, July 2005, Pages 27-36 (one partner)</i></p>
3. Impact on Innovation and Micro-economy		
A – Patents		
<p><u>Question 3.1.</u></p> <p>Patents filed and pending</p>		N/A
<p><u>Question 3.2.</u></p> <p>Patents awarded</p>		N/A
<p><u>Question 3.3.</u></p> <p>Patents sold</p>		N/A
Questions about project's outcomes	Number	Comments or suggestions for further investigation
B - Start-ups		

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<p><u>Question 3.4.</u></p> <p>Creation of start-up</p>	No	
<p><u>Question 3.5.</u></p> <p>Creation of new department of research (ie: organisational change)</p>	No	
C – Technology transfer of project's results		
<p><u>Question 3.6.</u></p> <p>Collaboration/ partnership with a company ?</p>	Yes	<p>Which company : Bosch</p> <p>What kind of collaboration ? Master Thesis about automotive network integration by the COSMIC event model.</p>
4. Other effects		
A - Participation to Conferences/Symposium		
<p><u>Question 4.1.</u></p> <p>Active participation¹ to Conferences in EU (specify if one partner or "collaborative" between partners)</p>		<p>Informatik 2001: Joint Annual Conference of the GI/OCG, Workshop on Mobile Communication over Wireless LAN: Research and Application, Sept. 25-28, 2001 (one partner)</p> <p>ISADS 2003 Workshop on European Research on Middleware and Architectures for Complex and Embedded Cooperative Systems, Pisa, Italy, April 2003. (collaborative)</p> <p>RTSS 2004 Workshop on Architectures for Cooperative Embedded Real-Time Systems (WACERTS), Lisbon, Portugal, Dec. 2004. (collaborative)</p>
<p><u>Question 4.2.</u></p> <p>Active participation to Conferences outside the EU (specify if one partner or "collaborative" between partners)</p>		<p>OOPSLA 2002 Workshop on Engineering Context-Aware Object-Oriented Systems and Environments (ECOOSE), Seattle, WA, USA, Nov. 2002. (one partner)</p> <p>International Workshop on Dependable Embedded Systems, October 17, 2004, in conjunction with the 23rd IEEE Symposium on Reliable Distributed Systems (SRDS 2004), Florianopolis, Brazil (one partner)</p>

¹ 'Active Participation' in the means of being an invited speaker or organising a workshop / session / stand / exhibition directly related to the project (apart from events presented in section 2).

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B – Training effect		
<u>Question 4.3.</u> Number of PhD students hired for project's completion	11	Seven in Computer Science. One in Middleware for embedded systems One in Predictable protocols for wireless communication Two in Dependable real-time systems
Questions about project's outcomes	Number	Comments or suggestions for further investigation
C - Public Visibility		
<u>Question 4.4.</u> Media appearances		N/A
<u>Question 4.5.</u> "Good" picture produced (i.e.: photos, drawing)		N/A
<u>Question 4.6.</u> "Good" video produced		N/A
<u>Question 4.7.</u> Outstanding presentation		N/A
D - Spill-over effects		
<u>Question 4.8.</u> Any spill-over to national programs	Yes	1. Further research in this area is being funded by Science Foundation Ireland. 2. ESF Minema.
<u>Question 4.9.</u> Any spill-over to another part of EU IST Programme	No	
<u>Question 4.10.</u> Are other team(s) involved in the same type of research as the one in your project ?	Yes	For instance, the following research projects are related to issues investigated in CORTEX: <ul style="list-style-type: none"> • EGadgets (Extrovert Gadgets) IST-2000-25240 • EMOTION: EMObile Testbed for Interoperability of Networks in eLogistics (IST-2001-36059) • EYES (energy-efficient sensor networks) (IST-2001-34734) • GLOSS (IST-2000-26070) • MobileMAN : Mobile Metropolitan Ad hoc Network (IST-2001-38113)

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| | | <ul style="list-style-type: none">• NOMAD: Integrated Networks for Seamless and Transparent Service Discovery (IST-2001-33292)• Pepito (IST-2001-33234)• Secure (IST-2001-32486)• Smart-Its (IST-2000-25428)• 2WEAR (IST-2000-25286)• 3GT: 3rd Generation Telematics (IST-2001-36080) |
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