

PDF - EMBEDDED EVERY-WHERE: A RESEARCH AGENDA FOR NETWORKED SYSTEMS OF EMBEDDED COMPUTERS - researchcub.info ions and models for developers. companies. Expanding access to this data by more researchers is an important role for a government agency. The committee believes that NIST also has a particularly critical role to play in this realm as the agency that establishes confidence in information systems. NIST is seen as an outside observer that can provide objective services and analysis. It has an important role in the standards development process, allowing the work done in industry to be illuminated in a fair and open fashion. As this report has emphasized, interoperability for EmNets will be very important, and standards will be needed for such interoperability. Given that many of the standards in this arena are likely to arrive as de facto rather than de jure standards, NIST can provide an objective analysis of them and reduce barriers to entry with reference implementations of the technology itself and/or reference implementations of conformance testing tools. More specifically, NIST, through activities such as its Aroma Project,¹⁷ which focuses on testing, ¹⁷For more information, see <<http://www.nist.gov/aroma/>>. Embedded, Everywhere: A Research Agenda for Networked Systems of Embedded Computers Copyright National Academy of Sciences. All rights reserved.

CONCLUSIONS AND RECOMMENDATIONS

199 measuring, and standardizing pervasive computing technology, should play a significant role in the two areas as EmNets become ever more widespread.

Recommendation 3. The National Institute of Standards and Technology should develop and provide reference implementations in order to promote open standards for interconnectivity architectures. It will be important to promote open standards in the area and promote system development using commercial components by making public domain device drivers available.

Recommendation 4. The National Institute of Standards and Technology should develop methodologies for testing and simulating EmNets in light of the diverse and dynamic conditions of deployment. Comprehensive simulation models and testing methodologies for EmNets will be necessary to ensure interoperable, reliable, and predictable systems. In particular, the development of methodologies for testing specification and interoperability conformance will be useful. In the process of these endeavors, NIST can play a key role in data collection and dissemination of EmNet-related information for use by the larger research and development community.

Recommendations to the National Science Foundation The National Science Foundation (NSF) has a strong track record in promoting multidisciplinary research and integrated research and education programs. More recently, it has been increasing its support for integrated systems projects—for example, the Information Technology Research (ITR) program. All three areas—multidisciplinary research, integration of research and education, and integrated systems approaches—will be of great importance in the support of EmNet-related research projects, and all of them—in particular, systems-oriented work—should be aggressively pursued and include cross-divisional efforts where necessary. Specific recommendations for NSF are below.

Recommendation 5. The National Science Foundation should continue to expand mechanisms for encouraging systems-oriented, multi-investigator, collaborative, multidisciplinary research on EmNets. NSF is funding work in several areas related to

EmNets (see Box 6.6). Much of this work continues to be done by a single principal investigator (and graduate students) operating on a small budget. As noted in this Embedded, Everywhere: A Research Agenda for Networked Systems of Embedded Computers Copyright National Academy of Sciences. All rights reserved. 200 EMBEDDED, EVERYWHERE BOX 6.6 A Sampling of the National Science Foundation's EmNet-related programs Scalable Information Infrastructure and Pervasive Computing NSF is supporting work in scalability, security, privacy, sensors and sensor networks, and tether-free networking and communications in this program. Its goal is to advance the technical infrastructure to support human-to-human, human-to-computer, and computer-to-computer remote communication. Wireless Information Technology and Networks This program funds research to provide a foundation for designing high information-capacity wireless communication systems for full mobility. Such design will require synergistic, multidisciplinary research efforts encompassing a breadth of communications functions from the physical through application layers. Electronics, Photonics, and Device Technologies This program funds research in the areas of micro and nanoscale devices, components, and materials, advanced methods of design, modeling, and simulation of such devices and components, and improved techniques for processing, fabrication, and manufacturing. report, research on EmNets will require that such single investigator research be complemented by collaborative experimental research that brings together researchers from different disciplines to focus on a common problem. Had this report been written several years ago, it would have recommended that NSF move toward larger-scale, experimentally driven, risk-taking research. NSF's ITR program appears to be doing just that. ITR also reinforces attention to the social and economic dimensions of information systems. This program, or others like it, could serve as a useful vehicle for pursuing some of the topics pinpointed in this report. The key to achieving successful multidisciplinary research is not just a matter of funding levels. A flexible process is required that can incorporate perspectives from a broad range of relevant disciplines. Recommendation 6. The National Science Foundation should develop programs that support graduate and undergraduate multidisciplinary educational programs. Embedded, Everywhere: A Research Agenda for Networked Systems of Embedded Computers Copyright National Academy of Sciences. All rights reserved. CONCLUSIONS AND RECOMMENDATIONS 201 With respect to education (see Box 6.1), NSF could take the lead in tackling institutional barriers to interdisciplinary and broad systems-based work. NSF has a history of encouraging interdisciplinary programs and could provide venues for such work to be explored (as is being done in the ITR programs) as well as foster and fund joint graduate programs or joint curriculum endeavors. One way to do this would be to provide incentives to programs that successfully cross disciplinary boundaries. For example, faculty working on interdisciplinary research often have difficulty securing institutional support for work deemed outside the scope of their home department. A program that removed this drawback by providing funding for such work could stimulate interdisciplinary research and course material in colleges and universities. Another way would be to expand the Graduate Fellowship Program to support more interdisciplinary proposals. Suitable evaluations of

proposals would be needed to implement this recommendation. Recommendations to Other Federal Agencies The National Aeronautics and Space Administration (NASA) and the Department of Energy (DOE) were two of the earliest innovators and adopters of EmNets. While NASA and DOE application domains can be quite specialized, two things are clear: The computer science community would benefit from hearing of and seeing this earlier (and contemporary) work, and NASA and DOE themselves would benefit from the more general pursuit of this technology by the broader computer science community. Both agencies have long histories in systems engineering as well as in computer science and so could serve as a useful bridge between various communities, especially regarding the development of EmNets. NASA, for example, has a strong interest in safety and reliability, and DOE has long been involved in reliability issues. Their expertise, when applicable, could be shared with others in related research areas; in addition, the two agencies would benefit from the generalizations that the broader research community could provide. More explicit cooperation and communication would be beneficial to everyone and would greatly advance the field. The agencies with needs for EmNets should together promote expanded experimental research with a shared, experimental systems infrastructure. The committee expects that coordination needs could be supported by the various organizations and groups associated with federal information technology research and development.¹⁸ Open-platform systems¹⁸ The National Coordination Office for Information Technology Research and Development and related groups can facilitate cross-agency coordination, for example. Embedded, Everywhere: A Research Agenda for Networked Systems of Embedded Computers Copyright National Academy of Sciences. All rights reserved.²⁰² EMBEDDED, EVERYWHERE tems of various scales, low-power components and the software drivers for these components, debugging techniques and software, traffic generators—all can be shared across research programs when applicable, avoiding inefficient redundancy in those parts of the system where there is more certainty. The research communities should combine their efforts in creating enabling components, such as a range of MEMS-based sensors and actuators that are packaged in such a way as to be easily integrated into experimental EmNet systems.

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