

Embedded, Everywhere

A Research Agenda for Networked Systems of Embedded Computers

(Chapter 1)

Presented By: David Resseguie

April 15, 2003

About the Book

- Written By: Estrin et al
 - Committee on Networked Systems of Embedded Computers
 - Computer Science and Telecommunications Board
 - Division on Engineering and Physical Sciences
 - National Research Council
- Published By: National Academy Press, 2001
- Available Online:
http://bob.nap.edu/html/embedded_everywhere/index.html

Book Description

*"**Embedded, Everywhere** explores the potential of networked systems of embedded computers and the research challenges arising from embedding computation and communications technology into a wide variety of applications—from precision agriculture to automotive telematics to defense systems."* -- NAP website

This Presentation

- Introduction
- Motivational Examples
- Understanding Networked Systems of Embedded Computers (EmNets)
- How EmNets Differ from Traditional Systems
- Why a New Research Agenda
- Related Topics Not Covered in Book

Introduction

- What is an *EmNet* ?
- Current Trends
- A New Way of Thinking
- Research Challenges

Motivational Examples

- Automotive Telematics
- Precision Agriculture
- Defense Systems

Automotive Telematics

- Model year 2001
 - Between 20 and 80 Microprocessors
 - Engine
 - Breaking System
 - Airbag Deployment
 - Door Locks
 - Entertainment System
 - Etc.
 - Two Distinct Networks
 - Safety-Critical
 - Non-Safety-Critical

Automotive Telematics

- Move Away from Fully Engineered, Closed Systems
 - Disparity Between Design Cycles
 - Allow Easy Upgrade
 - Allow Owners to Integrate Other Devices
- Break Down Division Between Networks
 - Monitor for Upcoming Faults
 - Communicate Information to Manufacturer

Automotive Telematics

- Change from Self-Contained Network to a Node in a Much Larger Network
 - General Motors' OnStar
 - Other Systems being Prototyped
- Web Sites of interest:
 - <http://www.telematicsupdate.com>
 - <http://www.applied-telematics.net>
 - <http://www.telematicsdetroit.com>
 - <http://www.onstar.com>

Precision Agriculture

- Solutions Based on Large-Scale Averages are Suboptimal
- Precision Agriculture Allows Much Finer and Automated Granularity
- Automatic Adaptation to Changing Environments

Precision Agriculture

- Future Applications
 - Early Detection of Bacterial Development
 - Monitor Livestock for Viral Contamination
- Web Sites of Interest:
 - <http://www.precisionag.com>
 - <http://precision.agri.umn.edu>
 - <http://www.precisionag.org>

Defense Systems

- Battlespace Surveillance
- Asset Management
- Smart Materials and Structures
- Health Status Monitoring of Personnel
- Make Information Available to Individuals

Defense Systems

- Web Sites of Interest:
 - http://www.gcn.com/22_7/news/21603-1.html
 - <http://www.eetimes.com/story/OEG20010717S0036>
 - <http://www.engineer.ucla.edu/stories/2002/memsmag.htm>
 - <http://defence-data.com/features/fpage48.htm>
 - http://www.military.com/NewContent?file=NI_Balisle

Understanding EmNets

- Characteristics
 - Multiple Interacting Nodes
 - Embedded in Control Systems Without Human Intervention
 - Purpose Other Than General Computing and Communications
 - Natural or Engineered Contexts

Understanding EmNets

- Useful Distinctions
 - Energy-Constrained Nodes vs. Non-Energy-Constrained Nodes
 - Fixed Topology vs. Flexible Topology
 - Safety-Critical Applications vs. Non-Safety-Critical Applications
 - Highly Engineered vs. Unconstrained, Ad Hoc Systems

EmNets vs. Traditional Systems

“Incremental improvement to today’s solutions will not suffice to realize the full potential of EmNets.”

- *Tightly coupled to the physical world* and each other in a
- *Resource-constrained environment* that will
- *Persist for long periods of time* while consisting of
- *Many interacting components* and being
- *Used and interacted with by non-expert users*

Tightly Coupled to Physical World

- Interact Strongly with the Physical World
 - Sense the Physical World
 - Communicate and Process Data
 - Cause Physical Actions to be Taken
- Usability Issues
 - Users Think of Themselves as Interacting with the Object, Not a Computer
 - Open Opportunity for Usability Research

Resource-Constrained

- Nodes are Likely Untethered
- Important Constraints
 - Nodes
 - Organization
 - System Policies
 - Hardware
- Limit the Amount of Computation and Communication

Long Lifetimes

- EmNets have Much Longer Lifetimes than Traditional Systems
- Older Systems Must Interoperate with New Developments
- Ability to Upgrade is Essential
- Battery Lifetime (*Not Mentioned In Paper*)

Size and Scale

- Potential for Networks to Grow Very Large
- Systems Designed to Work Properly at One Size, Often Fail at a Larger Size
- Cannot Develop EmNets Naively as Extrapolations of Existing Technology

Non-Expert Users

- Used by People with Little or No Systems Training
- Computing Systems Must Adapt to Users, Not the Other Way Around
- Expectations of Objects Different from Expectations of Explicit Computational Devices
- Potential Recipe for Disaster

Why a New Research Agenda?

- Characteristics of EmNets Demand New Kinds of Research
- Fundamental, Underlying Research Problems Must be Addressed
- Potential Impact Warrants Special Consideration
- Unique Technological Challenges

Why a New Research Agenda?

- Open Research Areas
 - Enabling Technologies
 - Ease of Construction
 - Self-configuration and Adaptability
 - Ensure Performance and Safety
 - Ease of Use
- Problems with Existing Solutions
 - Many Assumptions Don't Apply to EmNets
 - New Research may Provide Benefits to Traditional Systems

Related Topics

- Advanced Sensors and Actuators
- Public Policy Issues
- Commercialization Issues, Standards, and Business Models
- Stand-alone Embedded Systems and Other Networked Information Systems

Questions or Comments?

