GROUP 1

Air Traffic Control

John Knight
Vic Basili
John Goodenough

Part of weaving the new information fabric

Example: Air traffic control

New Systems:

- **single node control**
- **network management of air traffic**
- **ground support of traffic management**
- **system with ever changing requirements**
- **traffic volume increase**
- **all safety critical**

Example problem: Advanced Automation System failure as an example of how hard it is

Problem

How do you build a big system system on time and in budget

build such with ever changing requirements

extreme safety and availability requirements

distributed computing system

distributed control

strong performance requirements

Needs

This requires work in

- process - need to develop better processes for such systems
- product - product predictability, non-functional requirements such as reliability and availability

implying research in

- process modeling - process that allow you build such a system on time and in budget
- product modeling - building systems with a confidence interval on availability

If you can’t analyze it - you should not build it!

Research Directions

Thus we need (as examples)

- new design techniques that have analyzability built into the approach
- to develop comprehensive analytic techniques for non-functional requirements that are integrated into the system analysis
- ...

Going Up a Level

This implies research activities

- **software development approaches tuned and tailored to need**
- **software products and processes that can be analytically and empirically evaluated for context of use**
- **the integration of theories, tools and practices for software and system modeling**

GROUP 2

Crisis Management

Allen, Freeman, Scherlis

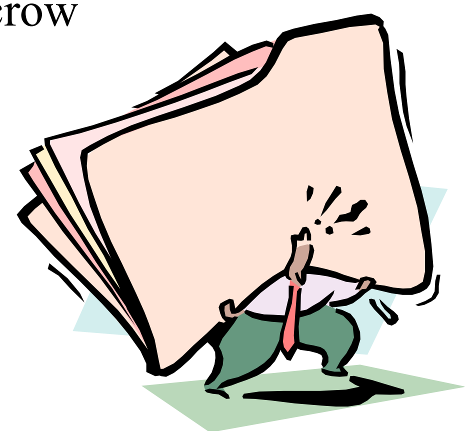
Crisis Management

- Phases
  - Planning
  - Preparedness/Mitigation
  - Response
  - Recovery
- Players
  - FEMA
  - State, Local
  - NGOs
  - Business
  - Citizens
- Diversity
  - Data inputs
  - Datbases
  - Applications

- Challenges
  - Multiple interdependent organizations
    - Federal/state/local, NGOs, utilities, private sector
    - Wide variation in access to IT resources
    - 1000s of organizations potentially involved
    - Command and control organization structure
  - Needs differ by phase
    - Preparation for rapid response
  - People under stress
  - Command and control
    - Situation awareness
    - Decision support

Crisis Mgmt Technologies (examples)

- Reliable communications
- Information integration
  - Multi-source data analysis
  - Variable quality
  - Geographical info
- Modeling and simulation
- Instant bureaucracy
- Situation awareness
- Collaboration
- E-Commerce
  - Supply chain assembly
    - Inventory mgmt
  - Single point-of-access
    - Information
    - Transactions
  - Trust relationships
    - Reconfigurable authorization
  - Citizen authentication
  - Information escrow



CM Technical Difficulties

- Composition
  - Rapid integration of subsystems/components
    - Overcome incompatibilities (Mary's chart)
    - Understand/express component attributes to enable predictable integration
  - (Rapid information integration)
    - Schema capture/expression
  - Rapid adaptation of components and systems (component assemblies)
    - With predictable results
  - (Models and simulations)

CM Technical Difficulties

- Analysis, Assurance, and Validation
  - Managing security-vs-responsiveness
    - Dynamic
  - Validation of integration
    - Quality metadata
    - Compositionality
      - Predicting characteristics of the aggregate from characteristics of components
    - The "good-enough" test
      - Units, Order-of -magnitude, Reasonableness
  - Exercises
    - Include the IT dimension
  - Augmented reality
    - Modeling ←→ Reality
    - Model readiness

CM Technical Difficulties

- Human interface
  - Rapid creation of new human interfaces
    - Responders
    - Citizens
    - Business
  - Collaboration
    - CM teams
      - Software engineering teams
    - Communities

CM Technical Difficulties

- Code-ifying
  - Domains
    - FEMA business rules
    - Information policy: privacy, access
    - Response processes
    - Situation awareness
  - Analysis
    - Consequences of access changes
    - Business rule interactions

CM Technical Difficulties

- Software Swat
  - Examples
    - Rapid adaptation / reconfiguration
  - Processes and predictability
    - Adjustment of features, quality, performance

GROUP 3

Deregulated, Net-Centric Industry

DeMillo, Medvidovic, Sullivan

Overview

- Motivation
- Vision
- Evolution + Integration
- Goals
- It's Hard
- Software engineering
- Why not just e-commerce
- Why should NSF invest

Motivation: Industry Trends

- Net-centric disintermediation
- Example
  - loan with online bank, they purchase risk who purchases debt who purchases money from fed
- Compelling economics
  - E.g., $30B on telecommunictions software
- Ubiquitous: firms, borders, industry sectors
- Software engineering is the problem
  - vast bulk spent on deregulation (not new systems), probably same for ERP, insurance, transportation, banking ...

Vision, Objectives

- Everyone empowered
  - under control of the end user
  - at all levels, in all industries
- Enormous efficiencies
- "Personal value chain engineering"
  - portal gives you design environment for composing chains on the fly; automatic dynamic optimization

Evolution and Integration

- Built largely on evolving, COTS foundaiton
- Can’t rebuild everying, heavily invested
- Built on models based on history
- Might severely lack needed modularity
- Have to restructure to support old and new
- Closed systems have to be opened up
- Opened-up systems have to be integrated

Goal

- Confidence in system-wide properties
  - Example: Utilities have to open up to competitors; how do you test that?
- Predictability
  - you start chaining together business processes; you need to know that you won't be without power for six hours

New Context Changes Nature of Problems

- Generalize from virtual enterprise to whole industry segments, networks of industries
- Not top down, but composition of heavily constrained systems into systems of systems
  - Not mapping requirements or specifications to design artifacts, but rather very high-level models (descriptions of how collections of enterprises operate), traditional traceability; you have constraints on system but now we generalize to: required properties of systems of systems each carrying its own reqs

Some New Issues

- Massive scale evolution and integration
- Collaborators and adversaries
- Competition, intellectual capital protection, authentication and contract monitoring

Some Critical Subdisciplines

- Software evolution
- Mega-scale Integration
- Software architecture
- Software economics
- Modeling & analysis
- Analysis and testing
- Requirements engineering
- COTS-based systems
- Modernization: generalizes Y2K, Security...

Foundations for Integration

- Service level agreements
- Compliance monitoring, enforcement
- Industry-scale integration architectures

Foundations for Decapsultion

- E.g., Automatic program understanding tools that can find where some important processing is taking place, and open it up

- Today an adjudicated process, it’s not until someone complains that you figure out what the problem was--not an efficient process

Isn’t this Just E-Commerce?

- Intelligent control of these supply chains;

- This is e-commerce domain, but software engineering problems are severe and on the critical path, c.f. $30B in telecom industry

Why NSF Invest?

- Huge payoff potential
- Fundamental research
- Industry can’t do it alone
  - time scale is too long
  - no investment payoff for one industry
  - within industry hard to see commonalities

GROUP 4

Education

- Software engineering underpinnings to enable Lifelong learning – cradle to grave
  - Require highly interactive and collaborative systems to support active learning approaches
- Support different modes or learning
- Learning environment on a laptop
- Software systems grounded in education, social science research

Software Engineering Needs

- adaptability of systems to deliver appropriate content in appropriate way
  - changing with amount of current competence of learner in subject
- embodiment in appropriate abstractions of models of learning, and other knowledge about learners
- improved authoring tools

Software engineering needs (cont'd)

- improved tools for integrating information from multiple, heterogeneous remote sources;
- allow learners to create their own environments
- improved User-interfaces
- integration of education-related systems; student information systems;registration systems; financial systems (management)

GROUP 5

Embedded medical systems

- Empowering
  - enable people to live longer and healthier lives
  - treatment in inaccessible locations (in the air, out of country, in the ouback)
  - state of the art treatment without invasive procedures
  - treatment with full information (patient medical history)
  - dependable embedded care

SoftEng Scientific Base

- Modeling and analysis of real time systems
- Real time operating systems theory (dynamic scheduling, protocols)
- Reliable/spontaneous/active/deep networking
- Dependability provision(safety, privacy, reliability, noninterference)
- Dependability modeling and analysis
- HCI (mental models vs state automata)
- Requirements capture, validation and decomposition into provably dependable software systems
- Dynamic microcontroller synthesis
- Component based design of heterogeneous systems (adaptation, interoperability, composition theory, guided engineering,med plugins)

GROUP 6

Geographically Distributed Team-Based Collaboration

Examples of Distributed Collaboration

- Software development (example is Apache)
- Education: at the K-12 area, curriculum development
- Digital media and entertainment
- NSF: geographically distributed NSF panels, non-resident program managers; collaborative cross-disciplinary, cross-institutional proposal development

Key Properties of the Examples

- Non-technical users
- Dynamism
  - of individual participants
  - of devices
  - of goals
- Trust and security
- Off-line artifacts
  - synthesis between physical and virtual spaces
- Meetings, in all their forms
- Goals and objectives
- Processes and policies

What Research Does it Take?

- How we build it
- How we trust it
- How we help users

How we build it

- Software Architecture:
- Integration and reuse of pre-existing components and systems
- Distributed nature of change
  - include. configuration management
- Connectivity and information access
  - wireless, protocols and latency issues
  - (in conjunction with networking researchers)
- Information distribution
  - replication strategies, caching
  - (in conjunction with database researchers)

How we trust it

- Reliability and methods of testing and debugging
- Protecting integrity over time and in the field
- Security, customized to each application

How we help users

- User interfaces
  - Informality of goals
  - range of user skill
  - (in conjunction with HCI/CSCW researchers)
- Reacquiring context for work
  - both people and automated processes
- Process and policy support, esp. in the face of ambiguity and change
  - (in conjunction with behavioral scientists)

Underlying Science

- Models and representations (from lots of the above)
  - representation of off-line or remote objects or people
  - goals and processes
- Analysis and Prediction
  - Metrics and assessment of research
- Knowing the sociological effect of use, and understanding the reasons for use, non-use, and abuse

Related Disciplines

- Within computer science
  - CSCW and HCI
  - Networking
  - Databases
- Behavioral scientists
- Domain experts (e.g. educators, entertainment producers, policy makers)

GROUP 7

Medical Informatics

- Reweaving the Healthcare System
  - Improving accessibility of existing medical data and process
  - Creating important new data and process
  - Improving functioning of medical bureaucracy
  - Fusion of all of the above
- Supporting “Empowering”
  - Everyone full access to relevant medical knowledge
  - Protecting privacy
  - Improving physician knowledge

Medical Informatics Sci. Underpinnings

- Process technology
  - capturing therapeutic protocols
  - Legal, regulatory, business rules
- Data fusion (multimedia: images, sound, motion)
  - A lot of science here: mastery of complexity is the core problem, but also basic software modeling science, connections to life sciences, Data mining
- Trouble-free, ultradependable systems
  - Science: analysis and reasoning about complex systems, dependable systems
- Usable, user-controllable interfaces
  - Science: making interfaces suitable for life-critical applications
- Group collaboration at a distance
  - Worldwide awareness
- Balancing availability with privacy, anonymity
  - Science: security, privacy
- Assisted diagnosis
  - Science: decisions support systems for life-critical applications
- Multiple stakeholder negotiation