Institute for Software-Integrated Systems (ISIS)

Dr. Janos Sztipanovits

ISIS Parameters

- Established by the School of Engineering at Vanderbilt University in 1998
- Academic/professional research organization
- Composition:
  - 29 Research Scientists & Engineers
  - 5 Faculty
  - 3 Admin Staff
  - 27 Graduate students
Research Thrusts
Core technology

- Model-Integrated Computing
  Meta-programmable modeling tools, model-synthesis tools, generators, and open tool integration platform for model-based design

- Distributed Object Computing
  Open source RT CORBA, model-based integration technology above the CORBA Component Model

- Model-Based Design
  Diagnosis, fault-adaptive systems, structurally adaptive systems

Sponsors

- NSF
- DARPA/DoD
- NASA
- Sandia Nat. Labs
- USAF
- DoD/ACTD
- ONR
- Saturn/GM
- Boeing
- DuPont
- Motorola
- IBM
- others…
Partners

IBM
BOEING
SwRI
BBN Technologies

• Physics
• Learning Science
• Nursing
• Medical School
• ME, ChemE, EE

Model-Integrated Computing
Process and Architecture

Metaprogramming Interface
- Formal Specifications
- Meta-Level Translation

Environment Evolution
- Model Builder
- Models
- Model Interpreters

Application Domain
- App 1
- App 2
- App 3

MIPS Environment
- Application Evolution

Meta-Programming Interface
**New Direction:** Combining MIC & Component Middleware

**Model-Based Generator**

- Select Component
- Synthesize & Assemble

**Model Driven Services Architecture**

- Finance
- E-Commerce
- Space
- Telecom
- Transportation
- Healthcare
- More

**CCM Model Library**

**CCM Component Library**

**Server/Peer Application Code**

- Component Home
- Container
- QoS Policies
- QoS Property Adaptor
- Real-time POA

**ORB QoS Interfaces**

**Client/Peer**

**Prof. Doug Schmidt**

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**ISIS at Vanderbilt**

**Leads or partners in interdisciplinary teams:**

- Physics Department (Prof. Paul Sheldon)
  BTeV Fault-tolerant RT Computer (NSF)
  (ISIS builds the tools and experimental computer platforms for the high-performance computer system of BTeV.)

- Physics Department (Prof. John Wikswo)
  Instrumenting the Cell (DARPA)
  (ISIS contributed to proposal development – pending option)

- BME ERC (Prof. Tom Harris)
  VaNTH (NSF-ERC)
  (ISIS develops the Learning Technology Infrastructure for VaNTH.)

- CEE Department (Prof. Mahadevan)
  Reliability and Risk Engineering (NSF-IGERT)
  (ISIS contributes to model-integrated reliability toolsets)

- ME Department (Prof. Ken Frampton)
  Smart Structure (DARPA; NSF)
Fault Detection, Isolation, and Recovery

- Domain-Specific Models of Space Station
  - Mechanical, Electrical, Failure Modes, Instrumentation

- Analyze System for Diagnosibility
  - Sensor Location
  - Fault Mode Distinguishability

- Synthesize Embedded, Real-Time Diagnostics Engine
  - Multiple/Temporal Faults, using Timed Failure Propagation Graphs
## Saturn Site Production Flow

**GM-Saturn**

### SSPF Model-Integrated Tools

- **Model-Integrated Program Synthesis Tool**
  - process models

- **Data Servers**
- **Bottleneck Tool**
- **Process Viewer**

- **Common Model Interface**

- **Domain-Specific Models of Automobile Production Plant**
  - Processes, Conveyors, Starving/Blocking, Throughput, Biz Procs, UI

- **Generate Site-Wide Data Integration System**
  - Real-Time Production History Database
  - Real-Time Client-Server Visualization Across Entire Plant

- **Productivity Enhancement Tools (+10% achieved)**
  - Bottleneck Analysis

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## Integrated Test Information System

**Arnold Engineering Development Center/Sverdrup Tech.**

### Information modeling tool
- information sources
- web interfaces
- legacy data systems

- **Data Infrastructure**
- **Web Server/ASP**
- **Security Manager**

- **Common Model Interface**

- **Domain-Specific Models of AEDC Distributed Data Systems**
  - Computers, Formats, Access Mechanisms, Security, UI, Web

- **Generate Test Information System**
  - Integrate Legacy Computers into a Real-Time, Distributed Database
  - Web-enabled secure access to real-time test data
  - Manage User Security/Permissions

- **Rapid System Specification and Evolution**
On-line Problem Solving Environment for Plant Operations

- Domain-Specific Models of Chemical Processing Plant
  - Process, Equipment, Math Models, Fault Propagation

- Generate Integrated Monitoring/Control/Simulation System
  - Real-Time Database
  - Integrated Chemical Plant Simulator (ASPEN)
  - On-Line Diagnostics

- Rapid System Specification and Evolution

Learning Technology

- Visual language for courseware authoring
  - Authoring from re-purposable learning resources (learning objects)
  - Instructional design patterns guided by learning science
  - Adaptive sequencing for individual learners

- Repository-based content management (eLCMS)
  - Web-based shareable resources for courseware authoring

- Model-based courseware delivery (eLMS)
  - Adaptable web-based delivery engine
  - Persistent records of learner experience

- Courseware authoring environment
  - delivery models
  - learning objectives
  - metadata

- 2000-2004
- NSF VaNTH ERC

- Deployed in 1994
- Used in Control Room
DARPA: Adaptive Computing

- Reconfigurable Systems Tool
  - Data Flow
  - Hardware Resources
  - Behavior

- Developed: 1997-2000
- Target ARMY/AMCOM

- Domain-Specific Models of Reconfigurable Embedded App.
  - Algorithms, Resources, Dynamic Behavior

- Generate Simulations & Dynamic Embedded Systems
  - Discrete Event Simulation
  - Custom Hardware Implementation
  - Heterogeneous, Parallel Real-Time Systems

- Rapid System Specification and Evolution

Boeing Aircraft Diagnostics

- Domain-Specific Models of Tool Data
  - Syntax & Semantics

- Generate Simulations & Dynamic Embedded Systems
  - Tool Adapters
  - Semantic Mapping Engines
  - Common Model Database

- Generation of Embedded Diagnostics
  - Diagnosis & Prognostics, Integrate Diverse Techniques
**DARPA: Distributed Logistics/ANTS**

- **Aircraft Maintenance Management**
- **Autonomous Negotiating Agents**

Development: 1999-2003

**Domain-Specific Models of Logistics Process**
- Suppliers, Consumers, Negotiating Strategies

**Generate Dynamic Negotiating System**
- Depot Agent/Negotiation Rules
- Consumer Agent/Negotiation Rules

**Funding Source:** DARPA, DoD/ACTD; Subcontractors: Boeing/MIT

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**Turbine Dynamic Structural Analysis**

- **Finite Element Analysis Real-Time Data ↔ Models**
- Development: 1995-2000
- Used at AEDC, Rolls Royce, GE

**Domain-Specific Models of Blade Vibration Analysis**
- Blade Structural, Material Properties, Data Systems

**Generate On-Line Simulation Coupled to Real-Time Data**
- Finite Element Analysis
- Dynamic Strain/Stress Computed
- Data Verification

**Blade Vibration Visualization**

**Coupled to Real-Time, Parallel Data Analyzer**
Space Shuttle Engine Health Monitoring

- **Real-Time Turbopump Monitoring**
  - High Speed DSP
  - Developed 1995-1998
  - Used at NASA/MSFC, SSC
  - Flown on STS-96

**Domain-Specific Models of Instrumentation System**
- Algorithms, Networks, Mapping

**Generate Embedded Real-Time Instrumentation System**
- Real-Time Analysis on Parallel DSP System
- Dynamic Visualization of Data
- Low-Latency, Real-Time Engine Cut-off Alarm

**Rapid System Specification and Evolution**

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Integrated Safety and Reliability Analysis

- **State Space Analysis Tool**
  - Behavior Models
  - Physical Models
  - Failure Models
  - Developed: 1996-2000
  - In use at Sandia National Labs
  - Used for validation of weapon systems

**Domain-Specific Models of System Behavior and Structure**
- System behavior, physical structure, component failures

**Model verification and validation**

**Automatic Fault Tree Generation**
- Safety/reliability fault trees can be generated from the integrated model
- Uses COTS fault tree analysis software
Motorola Cell-Phone Simulator

Domain-Specific Models of Cell Phone User Interface
- Menu’s, Options, Operational State

Generate Simulations Cell Phone
- Pre-build Testing
- Human Factors Analysis
- Run-Time Software Generation (Future)

Rapid Phone Operation Specification and Evolution

User Interaction Modeling Tool
- process models
- activity models

- Developed 1999
- Used in Motorola R&D

Future…

Common Model Interface

Simulator

(SW Generation)