	Day 1 — Mon, Sep 9	
7:30-8:30	Breakfast	
8:30-9:00	Session 1 Welcome, Introductions and Overview	
9:00-10:30	Session 2 Presentations (90 mins)	
	Hausi Müller (Organizer)	University of Victoria, Canada
	Gabriel Tamura	Icesi University, Colombia
	Norha Villegas	Icesi University, Colombia
10:30-11:00	Break	
11:00-12:00	Session 3 Presentations (60 mins)	
	Peter Hoh In	Korea University, Korea
	Jeong-Dong Kim	Korea University, Korea
12:00-13:15	Lunch	
13:15-14:30	Session 4 Presentations (90 mins)	
	Bashar Nuseibeh	The Open University, UK & Lero, Ireland
	Mazeiar Salehie	Lero, Ireland
	Liliana Pasquale	Lero, Ireland
14:30-15:00	Break	
15:00-17:00	Session 5 Presentations (60 mins)	
	Yijun Yu (Organizer)	The Open University, UK
	Arosha K. Bandara	The Open University, UK
	Pierre Akiki	The Open University, UK
	Lionel Montrieux	The Open University, UK
18:00-19:30	Dinner	

Victoria – Icesi EASSy Session

Software engineering @ runtime

Dynamic Context Management and Reference Models for Dynamic Self-Adaptation

Self-adaptive Software Systems: Properties and Assessment

Software Engineering at Runtime Situation-Aware Smart Applications

Hausi A. Müller
Faculty of Engineering
University of Victoria

Ideas That Will Change The World

University of Victoria | 50 YEARS | University of Victoria Engineering

NII SHONAN MEETING

Shonan Workshop on Engineering Adaptive Software Systems (EASSy)
Sep 9-12, 2013

Outline

Something profound is happening

Software engineering @ runtime

Our research projects

Something profound is happening …
The Smart Systems Revolution

Instrumented Interconnected Intelligent

Something profound is happening …

Instrumented

We now have the ability to measure sense and see the exact condition of practically anything.

Interconnected

People, objects, systems, and machines can communicate and interact with each other in entirely new ways.

Intelligent

We can respond to changes quickly and accurately and get better results by predicting and optimizing for future events.

Confluence of Sensors, Networks, Devices, Clouds, and Apps

At the core
self-adaptive systems

Confluence
Accelerating Global Innovation 2013

"The world is on the threshold of a new era of innovation and change with the rise of the **Industrial Internet**."

– Peter C. Evans,
GE Director of Global Strategy and Analytics

– Marco Annunziata,
GE Chief Economist

www.ge.com/sites/default/files/Industrial_Internet.pdf Nov 2012

Minds + Machines
November 29th, 2012

Powered by

Situational Awareness (SA)

- SA is the perception of environmental and personal context with respect to time and space
- Comprehension of its meaning and its projection into the future
- Critical to decision-making in complex, dynamic situations

- Applications
  - Mars Curiosity
  - Aviation—UAV, drones
  - Military command and control
  - Emergency services
- Applications
  - Driving a car
  - Crossing a street
  - Playing soccer
  - Playing basketball
  - Shopping

India

Mindboggling Situation Awareness

Shibuya, Tokyo

Humans are amazingly adaptive

Intuitively we know how critical and valuable context is.
But context is complicated.

"Context is the new battleground between
Android, iOS, Windows and
Apple, Google, IBM, Microsoft, Sony, Samsung, GE."

The Age of Context

When you have culture, context and competition working in synergy, you can achieve great gains.

Nate Silver, The Signal and the Noise

Telepathy One
Japan's Answer to Google Glass

Context through wearable computers

Takahito Iguchi
Inventor of Telepathy One

Stream of Context

Instrument and Capture the Stream of Context

Google

Stream of Context is Big Data

Instrument and Capture the Stream of Context

Killer Application

The Experiment—Volunteers

Stream of Context is Big Data

Self-Adaptive Systems (SAS)

- A SAS can alter its behaviour at runtime (on the fly) in response to its perception of
  - its environment
  - its own state

  by adapting itself

SEAMS

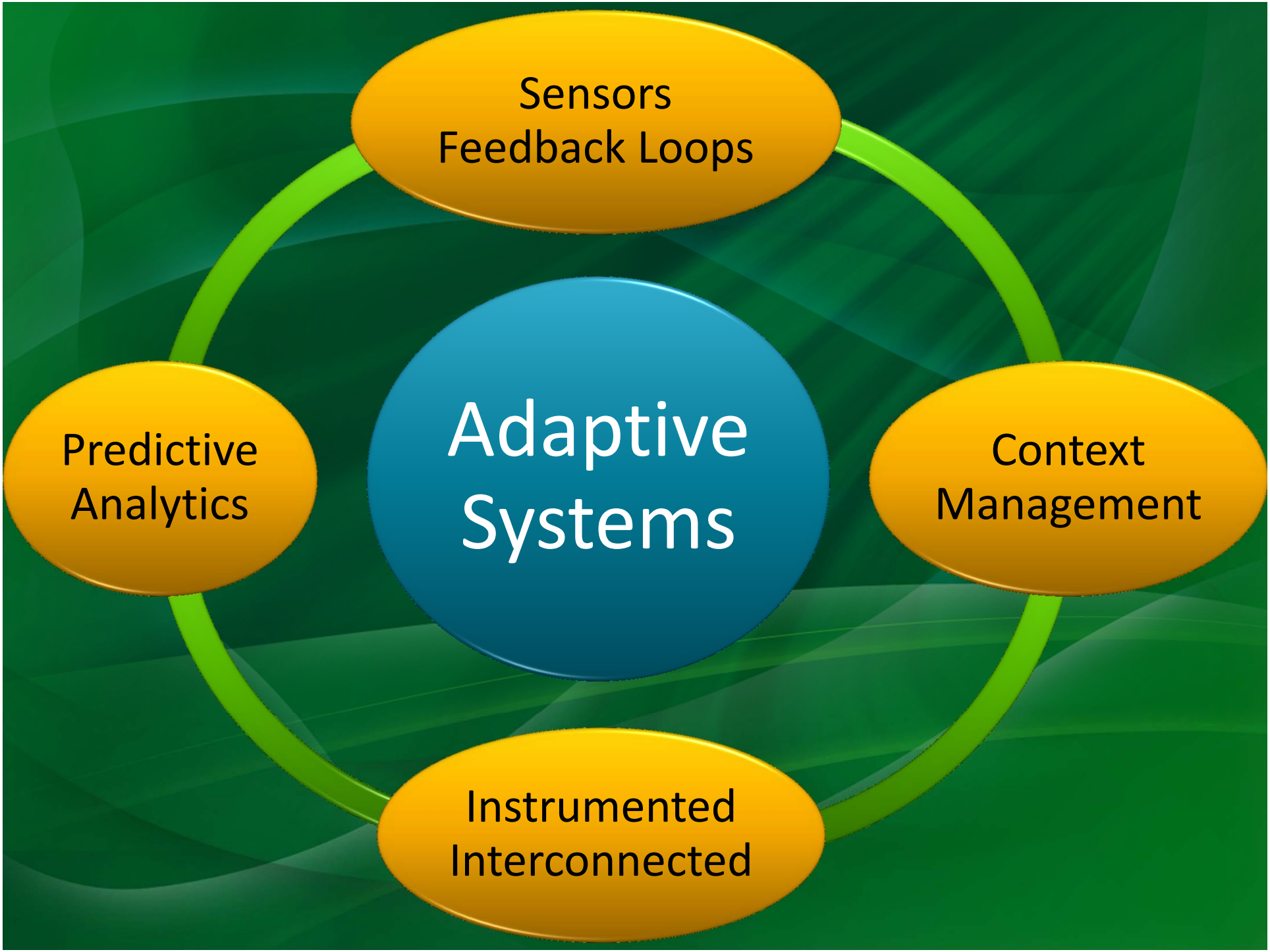
- SAS abilities
  - Assess its own behaviour
  - Observe its context or environment
  - Adapt without shut down

NII SHONAN MEETING

- Oreizy, et al.: An Architecture-Based Approach to Self-Adaptive Software, *IEEE Intelligent Systems,* pp. 54-62 (1999)
- MacManus: Why Software is More Important Than Sensors in the Internet of Things, ReadWriteWeb (2010)

Smarter System Characteristics

Smarter systems adapt at runtime


Sensors
Feedback Loops
Predictive
Analytics
Adaptive
Systems
Context
Management
Instrumented
Interconnected

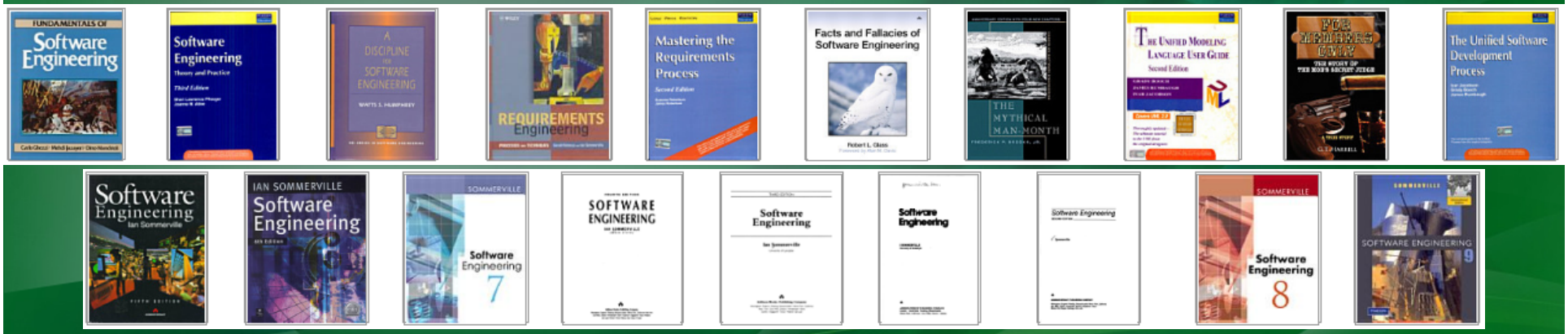
Outline

Something profound is happening

Software engineering @ runtime

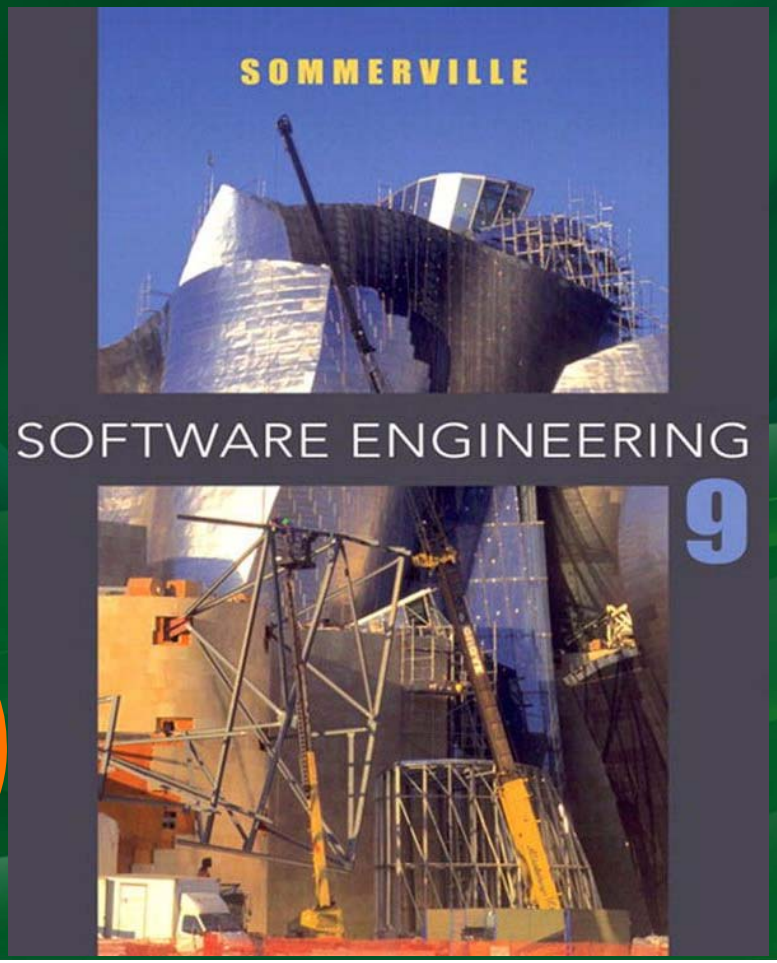
Our research projects

How should we teach the concepts of highly dynamical software systems in the age of context?



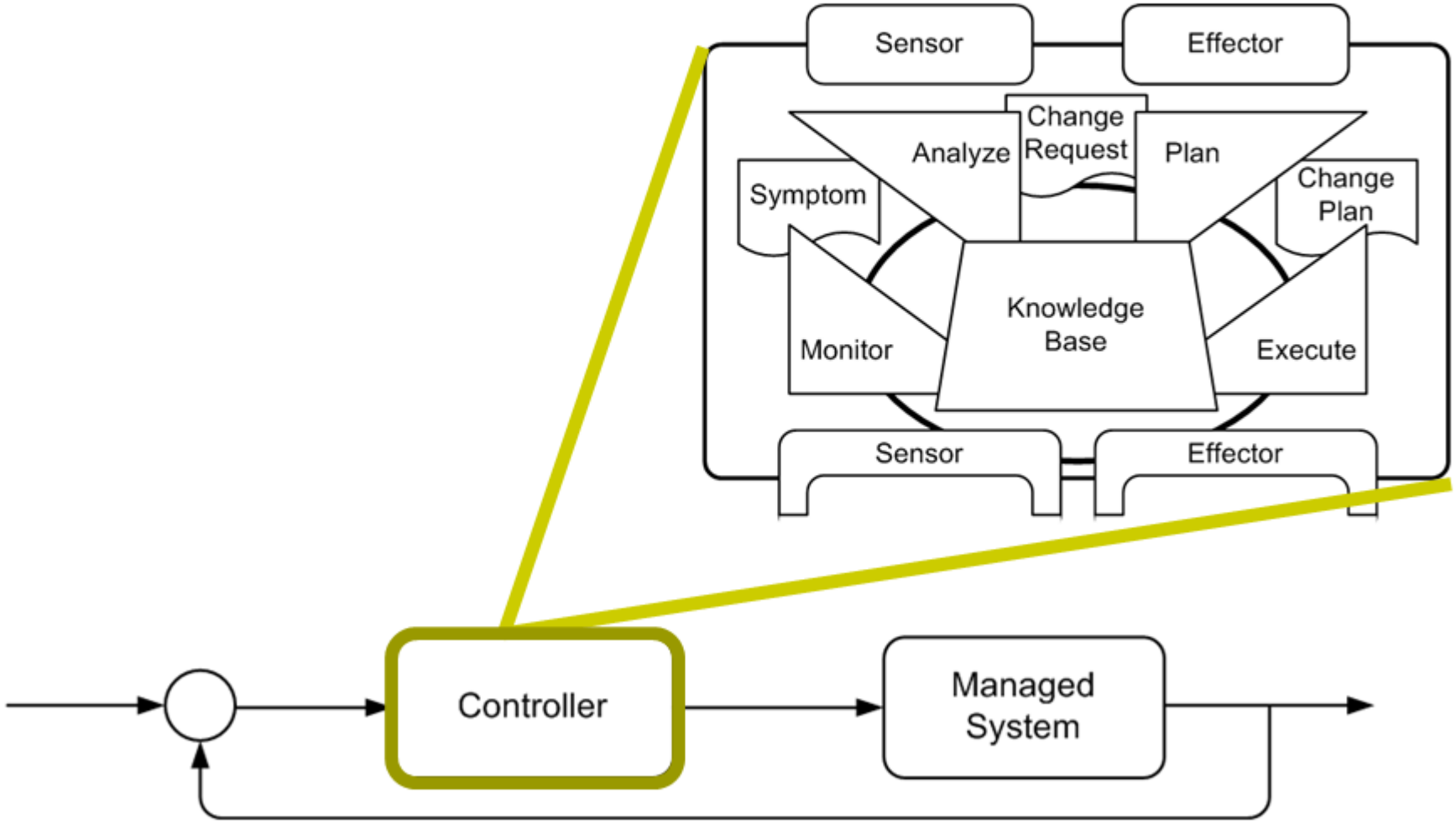
How do we integrate these topics into computing science and software engineering curricula?

Ian Sommerville
Software Engineering
9th Edition
2010



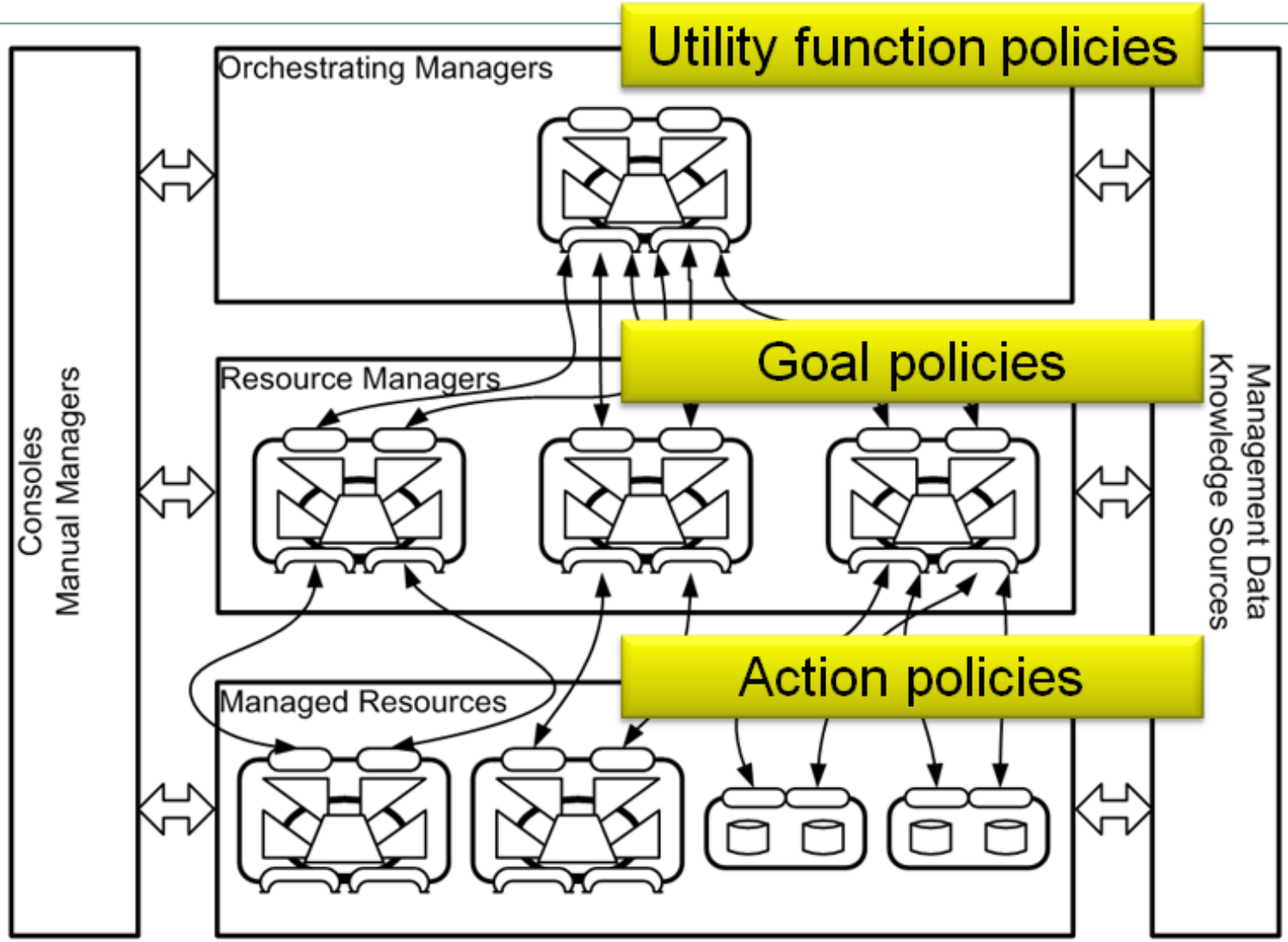
Contents at a Glance

Controller as an Autonomic Element

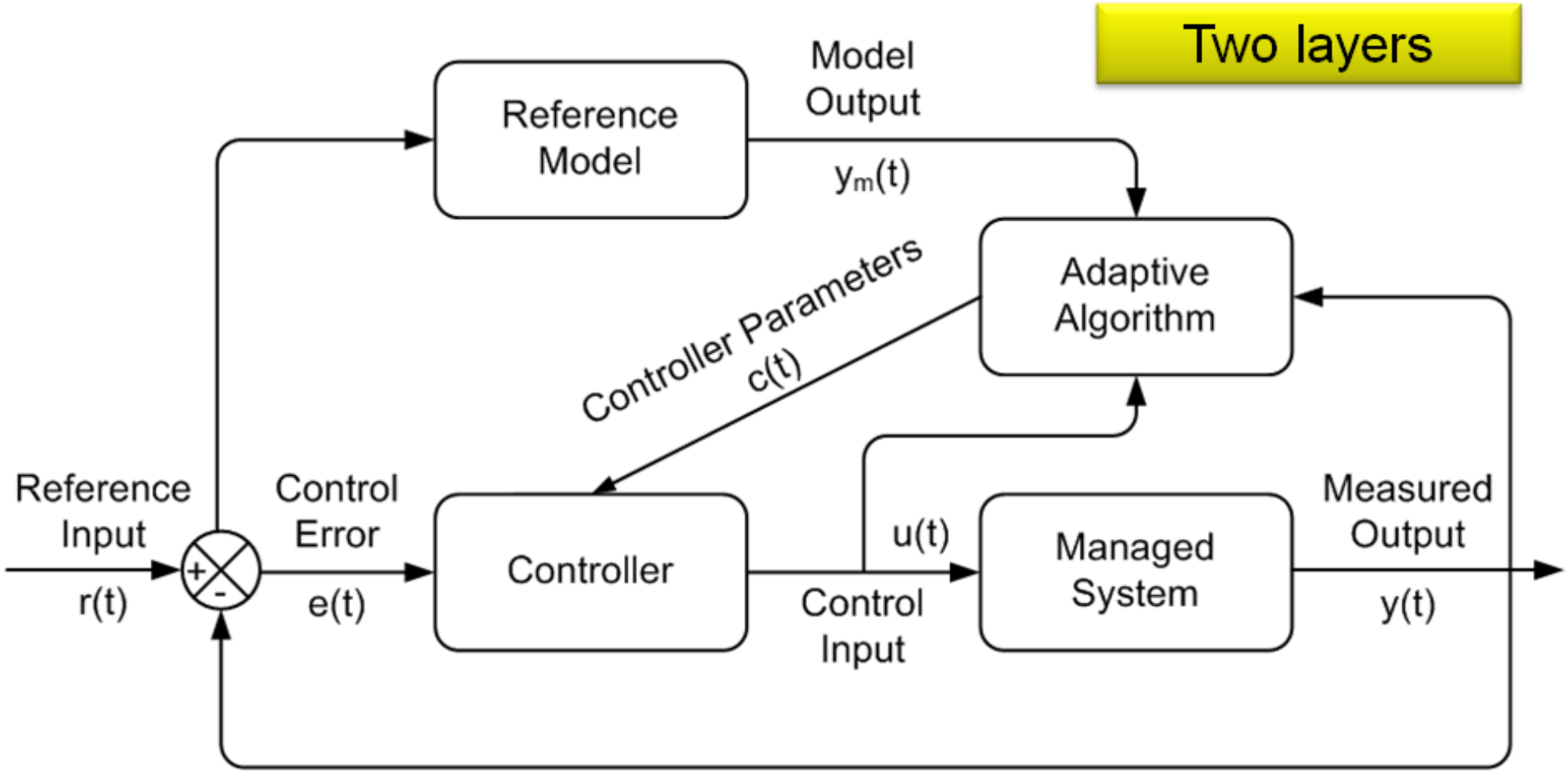


Autonomic Computing Reference Architecture (ACRA)

Hierarchy of Autonomic Elements

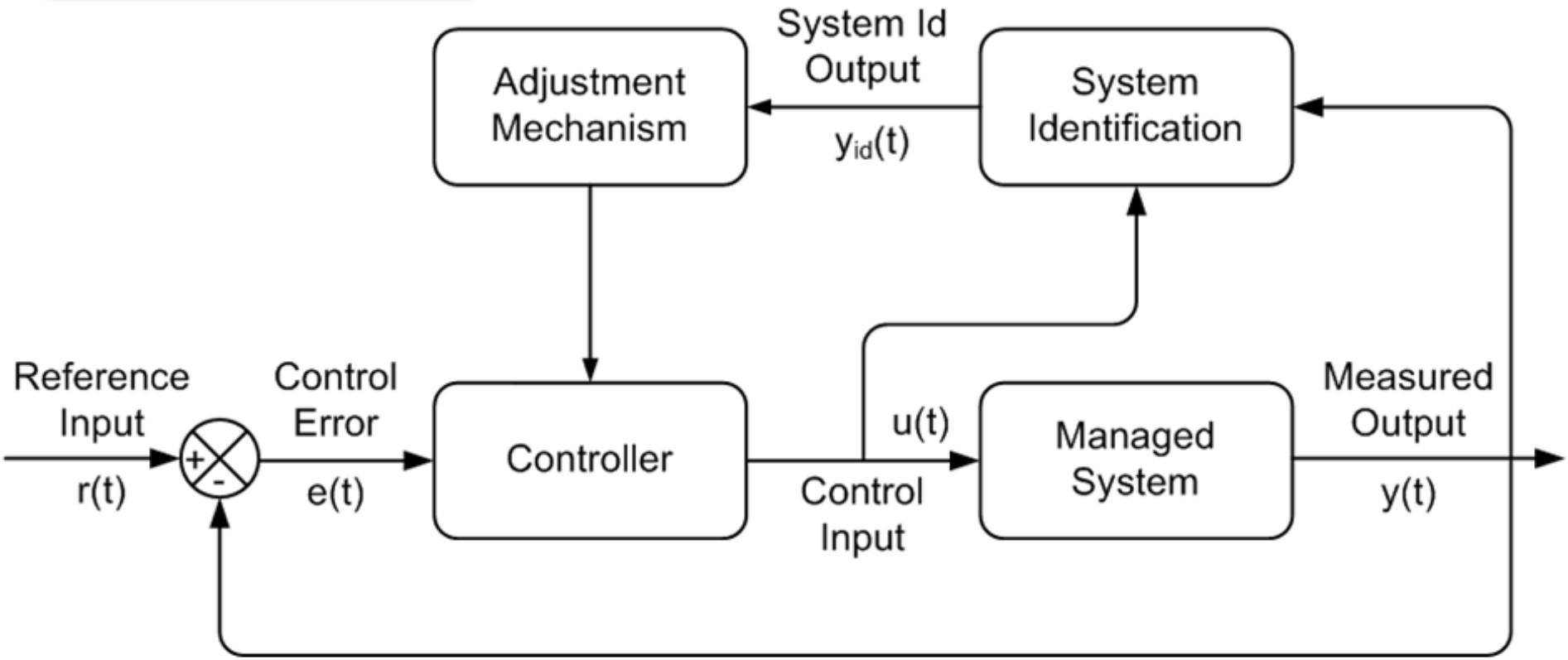


Adaptive Control—MRAC



Adaptive Control—MIAC

Two layers



Software Engineering @ Runtime

- Requirements@runtime
- Models@runtime
- Monitoring@runtime
- V&V@runtime
- Adaptation@runtime
- Analysis@runtime
- CM@runtime
- Assurance@runtime

- Profound impact on SE and CS
- Rethink software design and evolution for highly adaptive software systems
- Feedback loops and control theory are key

Boundary between development-time and run-time is disappearing

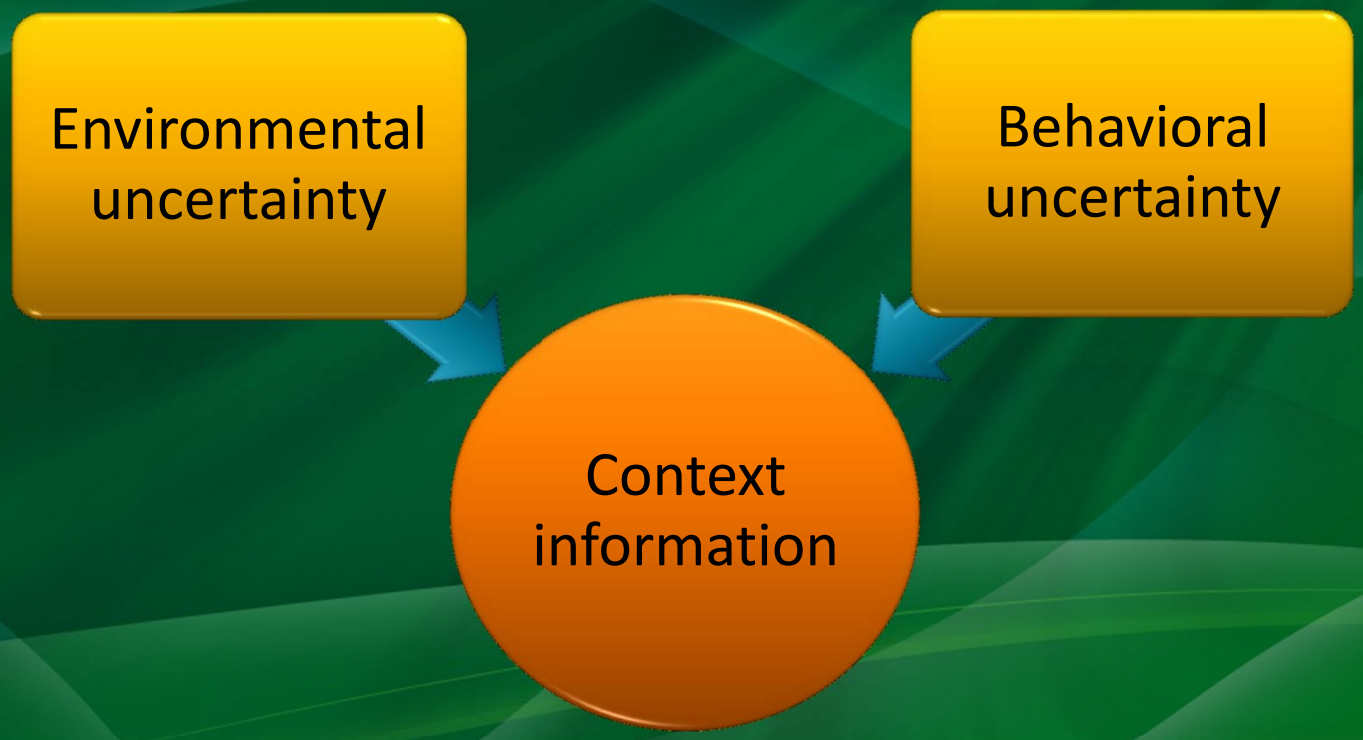
- Baresi, Ghezzi: The disappearing boundary between development-time and run-time. In: *FSE/SDP Workshop on Future of Software Engineering Research (FoSER 2010)*, pp. 17-22 (2010)

Models @ Run.time

- Runtime model representation and management
- Models @ Run.time need reflection
- Goal models for NF requirements
- Runtime verification of statecharts
- Dynamic context models
- UML behavioral models at runtime
- Applying MDE tools at runtime
- GUI runtime adaptation models
- Model synchronization
- Models for security analysis

- Bencomo: Workshop Series on Models@run-time, http://www.comp.lancs.ac.uk/~bencomo/WorkshopMRT.html
- Bencomo: Workshop Series on Requirements@run.time, http://www.comp.lancs.ac.uk/~bencomo/RRT/
- Dagstuhl Seminar: Models@run.time, 2011 http://www.dagstuhl.de/en/program/calendar/semhp/?semnr=11481

Context Models @ Runtime



- Coutaz, Crowley, Dobson, Garlan: Context is key, *CACM* 48(3) (2005)
- Whittle et al.: RELAX: A language to address uncertainty in self-adaptive systems requirements, *Requirements Engineering* 15(2):177-196 (2010)
- Inverardi, Mori: Feature-oriented evolutions for context-aware adaptive systems. In: *Proc. IWPSE-EVOL,* pp. 93-97, (2010)

UML 2.2 Seven Behavioural Modeling Diagrams

- Capture the varieties of interaction and instantaneous states within a model as it 'executes' over time
  - Track how the system will act
  - Observe the effects of an operation or event, including its results

8. Use Case diagrams
   - Model user/system interactions
   - Define behavior, requirements and constraints in the form of scripts or scenarios
9. Activity diagrams
   - Many uses; define basic program flow, capture decision points and actions
10. State Machine diagrams
    - Essential to understanding the run state of a model when it executes
11. Communication diagrams
    - Show the interactions between objects or parts in terms of sequenced messages
12. Sequence diagrams
    - Show the sequence of messages passed between objects using a vertical timeline
13. Timing diagrams
    - Fuse sequence and state diagrams to provide a view of an object's state over time
14. Interaction Overview diagrams
    - Fuse activity and sequence diagrams

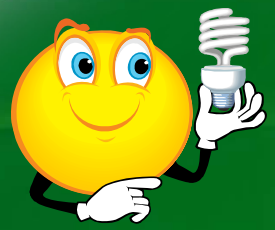
Interaction Diagrams

Requirements @ Runtime

- **From** satisfaction of requirements through traditional, top-down engineering

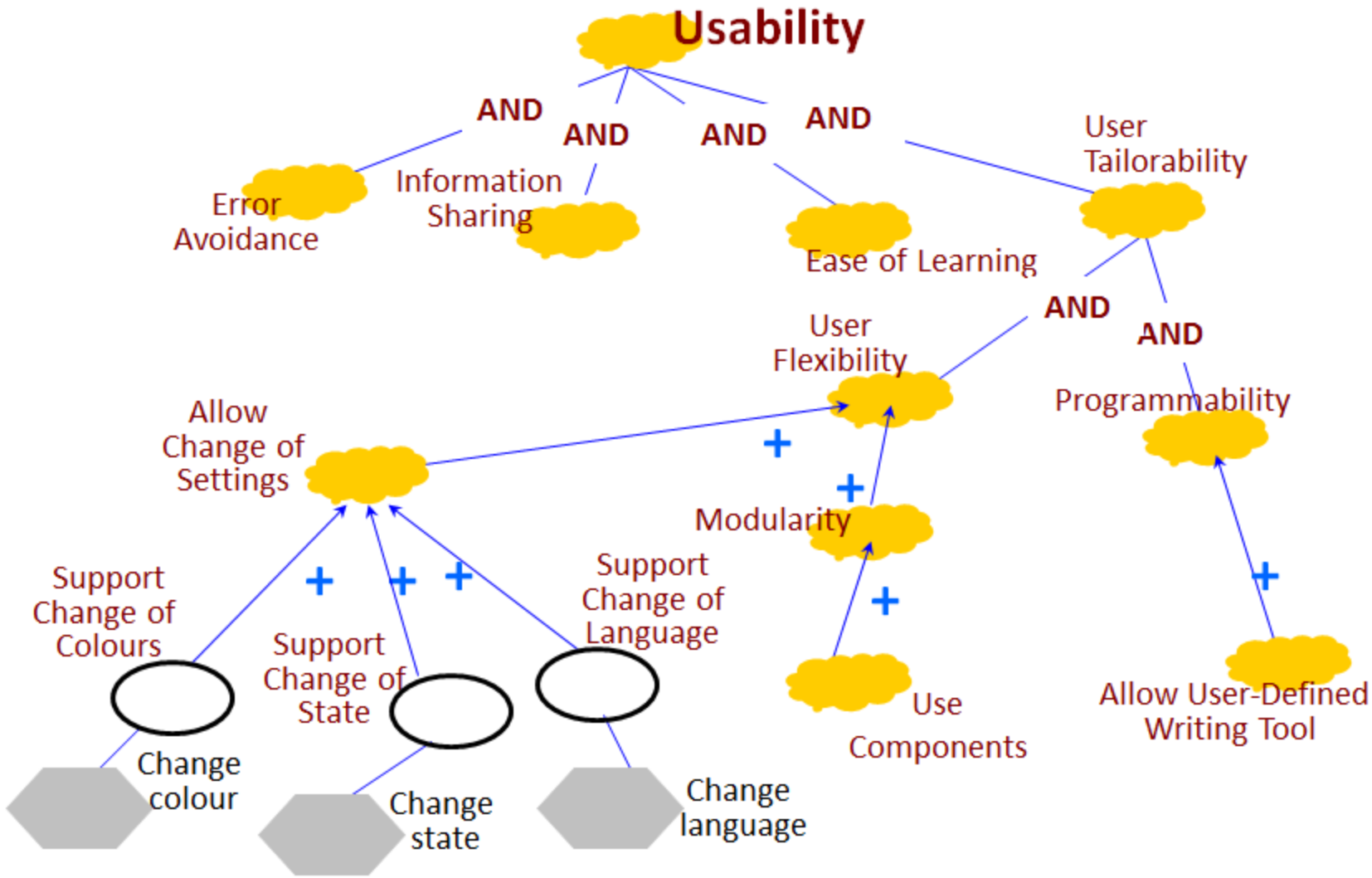
The system shall do this
… but it may do this …
… as long as it does this.

- **To** satisfaction of requirements by regulation of complex, decentralized systems



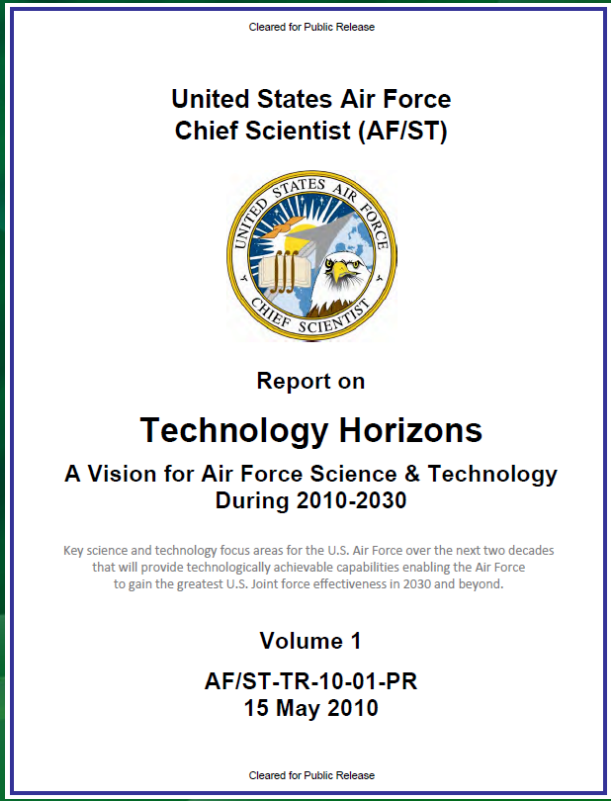
How much environment uncertainty can we afford? What's the cost?
What benefits do we accrue by accommodating context uncertainty?

A softgoal model



Assurance @ Runtime
Make V&V @ Runtime First Class

- V&V ensures that software satisfies requirements and quality attributes
- Runtime V&V ensures proper system operation during adaptation
- Certifiable V&V methods are critical for smart systems


Cleared for Public Release

United States Air Force
Chief Scientist (AF/ST)

Report on

Technology Horizons

A Vision for Air Force Science & Technology During 2010-2030

Key science and technology focus areas for the U.S. Air Force over the next two decades that will provide technologically achievable capabilities enabling the Air Force to gain the greatest U.S. Joint force effectiveness in 2030 and beyond.

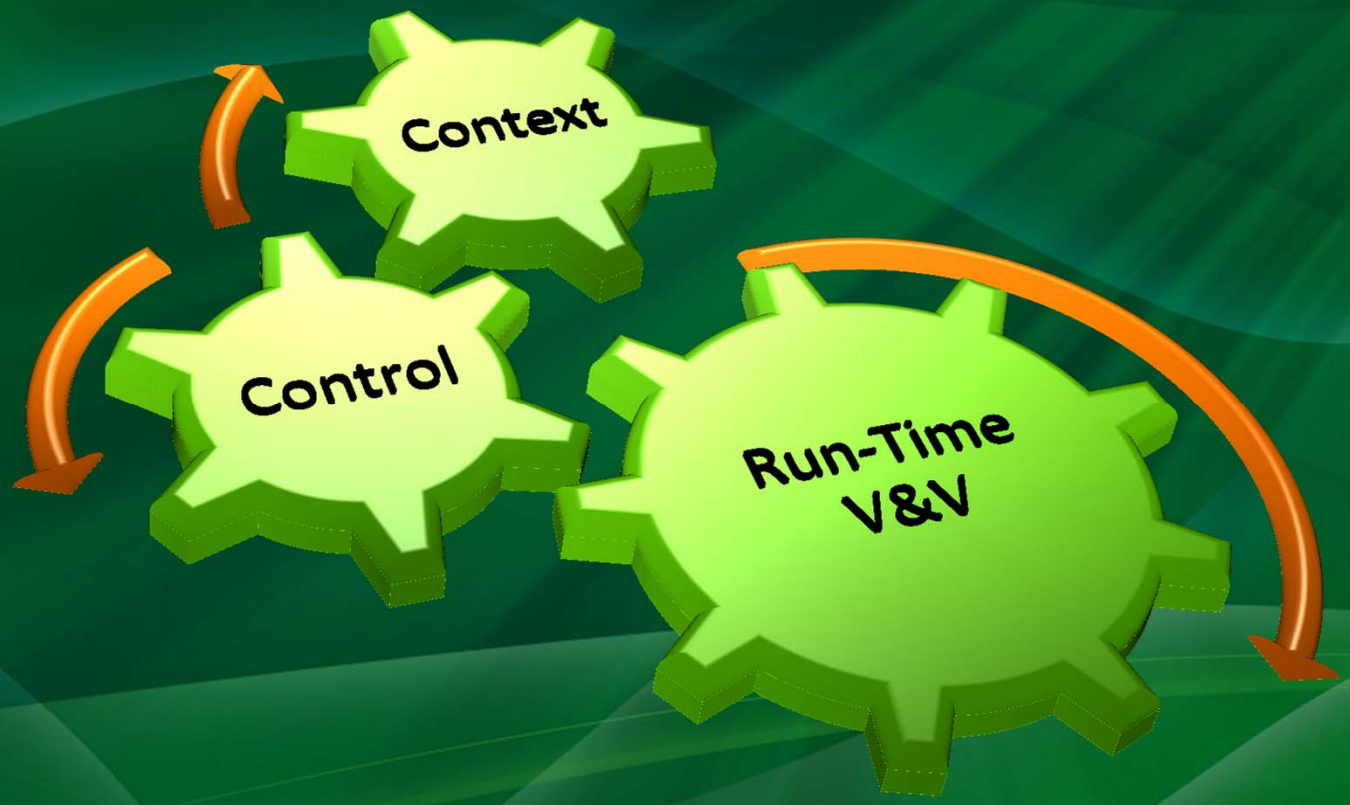
Volume 1

AF/ST-TR-10-01-PR
15 May 2010

Cleared for Public Release

- Dahm: Technology Horizons: A Vision for Air Force Science & Technology During 2010-2030. TR USAF (2010)
- Villegas, et al.: A Framework for Evaluating Quality-Driven Self-Adaptive Software Systems, In: *Proc. 6th ACM/IEEE Software Engineering for Adaptive and Self-Managing Systems (SEAMS 2011),* pp. 80-89 (2011)
- Tamura, Villegas, Müller, et al.: Towards practical runtime verification and validation of self-adaptive software systems. In: de Lemos, Giese, Müller, Shaw (Eds.), *Software Engineering for SAS,* Springer (2012)

Control Science



Control science can be defined as a systematic way to study certifiable V&V methods and tools to allow humans to trust decisions made by self-adaptive smart systems.

Outline

Something profound is happening

Software engineering @ runtime

Our research projects

Our Research Objective

Conduct fundamental research on situation-aware self-adaptive software-intensive systems to optimize their dynamic capabilities

Context Management

Feedback Control

Runtime V&V

Our Smart Systems Projects

- SAVI—Smart Applications on Virtual Infrastructure
  - NSERC Strategic Network
  - Desmarais, Castaneda, Jain, Bergen, Taheri
- SmarterContext—Smart Personal Web, Tasking
  - Villegas, Castaneda, IBM CAS
- YaKit—Smart Messaging System
  - Desmarais, Lach
- Smart Resource Management
  - Desmarais, Sowmya, Venkatesh
- SDDS—Smart Services
  - Pahlevan, Thomo
- Smart Phone Applications
  - Ebrahimi, Jain, Yang

Smart Applications on Virtual Infrastructure
NSERC Strategic Network 2011-2016

Principal Investigators (13)

- Alberto Leon-Garcia, Toronto
- Yashar Ganjali, Toronto
- Majid Ghaderi Dehkordi, Calgary
- Tho Le-Ngoc, McGill
- Baochun Li, Toronto
- Marin Litoiu, York
- Hausi Müller, Victoria
- Leslie Ann Rusch, Laval
- Kenneth Salem, Waterloo
- J. Gregory Steffan, Toronto
- Eleni Stroulia, Alberta
- Carey Williamson, Calgary
- Murray Woodside, Ottawa

Participating Companies (13)

- IBM CAS Toronto
- TELUS
- MTS Allstream
- Ciena
- Juniper Canada
- Cisco Canada
- Seawell Networks
- Nitido
- INSA
- CANARIE
- ORION
- Belair Networks
- Wesley Clover

Managing Dynamic Context to Optimize Smart Interactions and Smart Services
Norha M. Villegas

- User-driven context management framework
- Context models at three different levels of abstraction
- Context monitoring and reasoning engine
- Personal web sphere model
- Personal web case study
- **Goal: Make more offers to the user**

- IBM CAS Project of the Year 2011

SmarterContext.

Villegas, Müller: Managing Dynamic Context to Optimize Smart Interactions and Services, https://www-927.ibm.com/ibm/cas/cassis/viewReport?REPORT=747 (2011)

Confluence of Sensors, Networks, Devices, Clouds, and Apps

Something profound is happening ... The Smart Systems Revolution

Instrumented + Interconnected + Intelligent

Smarter Systems for a Smarter Planet

IBM

The world is getting smarter
More instrumented, interconnected, intelligent

Smart traffic systems | Intelligent oil field technologies | Smart food systems | Smart healthcare | Smart energy grids | Smart retail

Smart water management | Smart supply chains | Smart countries | Smart weather | Smart regions | Smart cities

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Summary

Control Science

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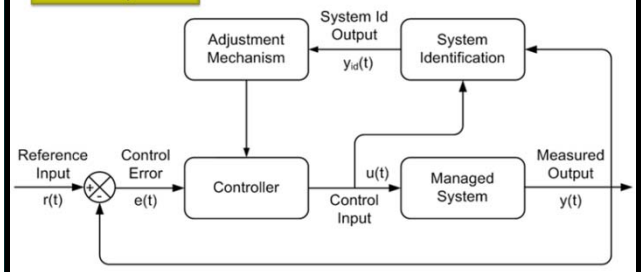
Adaptive Control—MIAC

Two layers



We need a new discipline

Software Engineering @ Runtime

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Conduct fundamental research on situation-aware self-adaptive software-intensive systems to optimize their dynamic capabilities