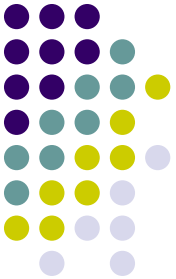
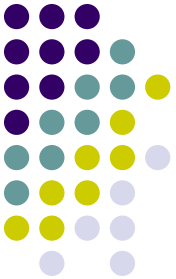


Welcome to SENG 480B / CSC 485B / CSC 586B Self-Adaptive and Self-Managing Systems

Dr. Hausi A. Müller
Professor
Department of Computer Science
University of Victoria

http://courses.seng.uvic.ca/courses/2013/summer/seng/480b
http://courses.seng.uvic.ca/courses/2013/summer/csc/485b
http://courses.seng.uvic.ca/courses/2013/summer/csc/586b

The Complexity Problem



Build a system used by millions of people each day administered and managed by a half-time person

— Jim Gray, Microsoft Research

Complex Heterogeneous Environment






Devices

Vendors & Applications



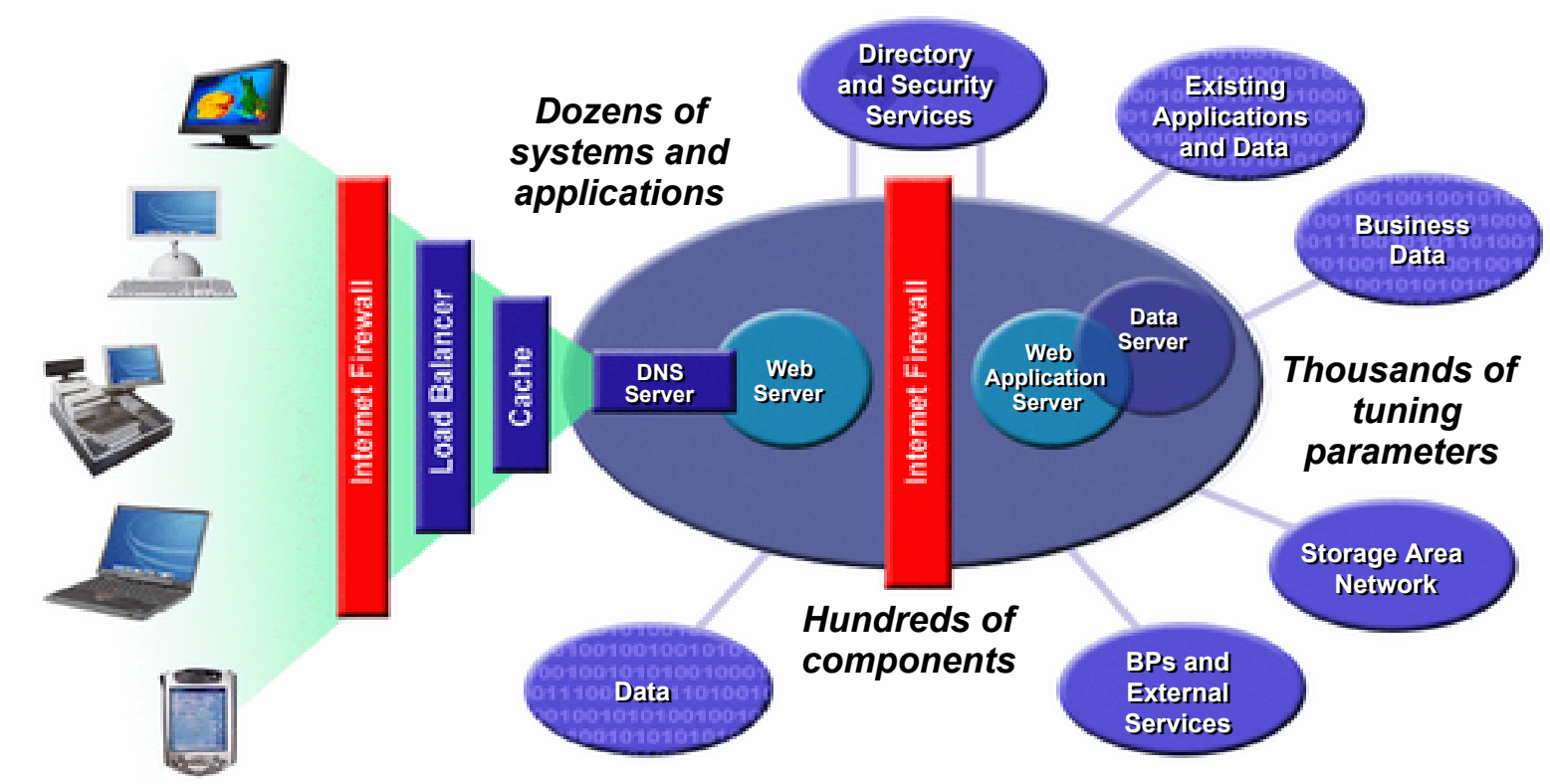



Users & Needs




Alan Ganek, VP IBM Autonomic Computing, 2003

Complex Heterogeneous Infrastructure



Alan Ganek, VP IBM Autonomic Computing, 2003

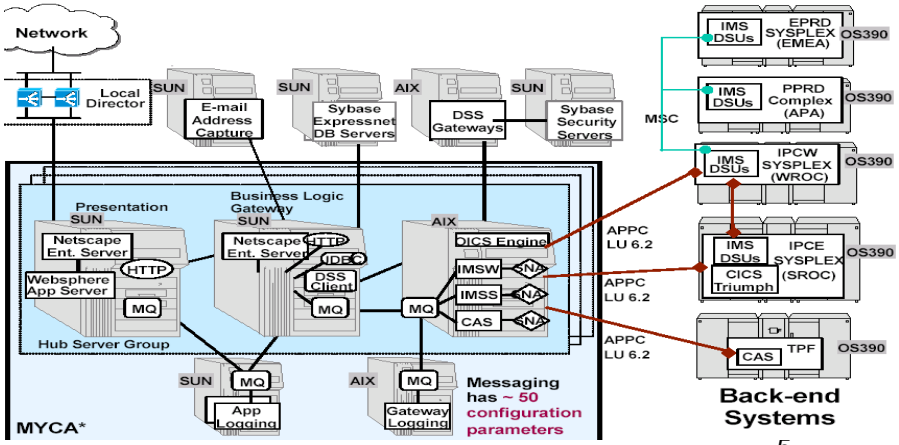
Complexity of Configurations

- Application Server
  - ~100 configuration parameters
  - Several applications
  - Hundreds of servlets
  - Tens of EJBs
- Web Server
  - ~20 configuration parameters
  - Serves thousands of web artifacts
- Messaging
  - ~30 configuration parameters
- DBMS, TCP/IP, OS …

Information systems are very complex for humans and costly to install an maintain

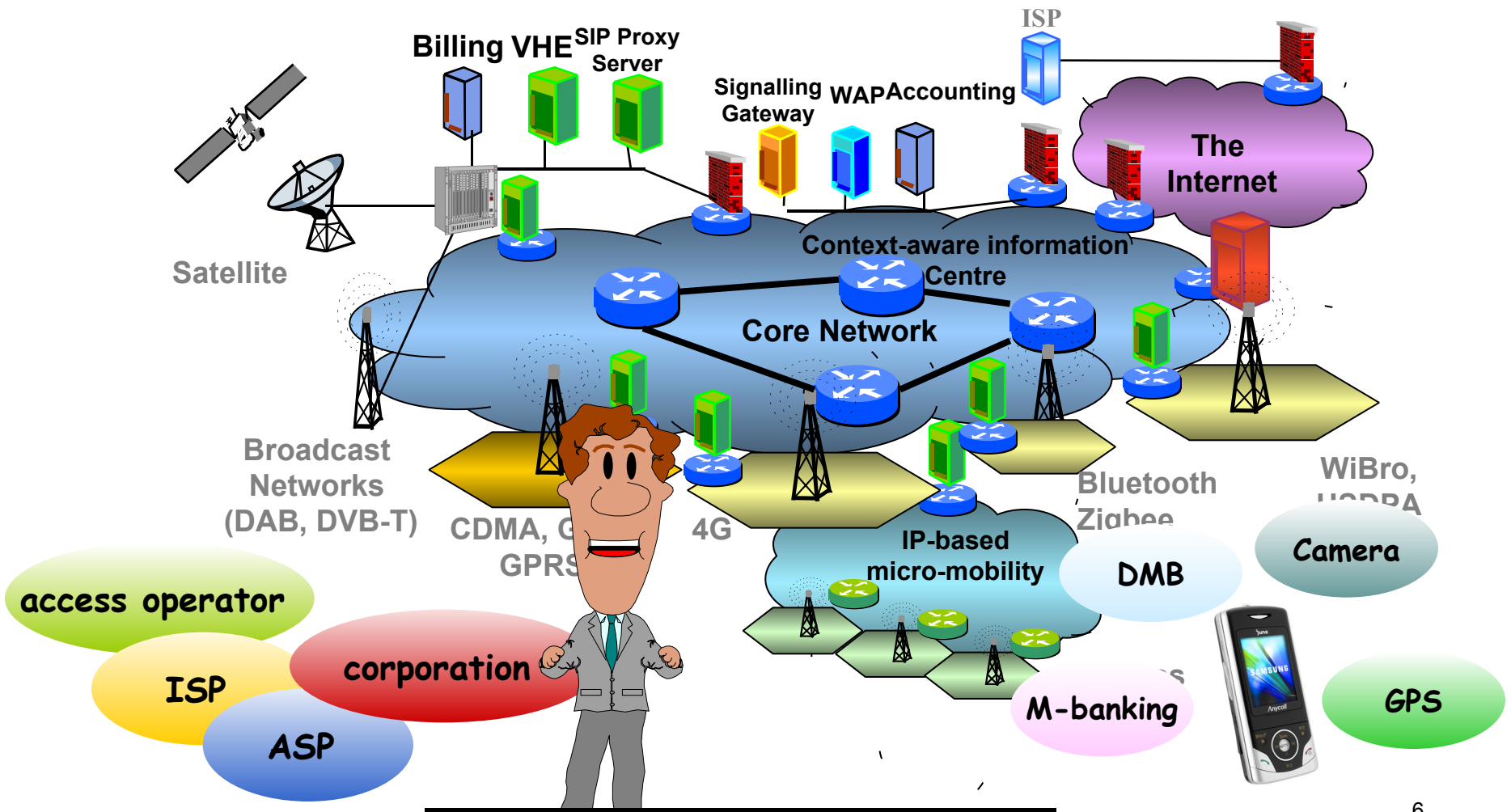
x 2-5 parameters

2^{150} settings

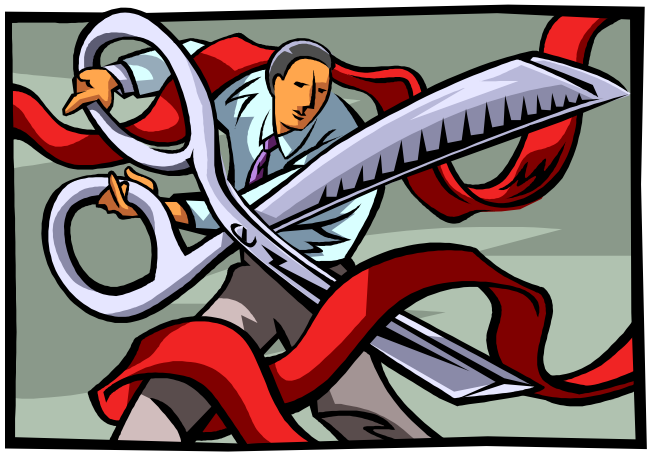


Marin Litoiu, IBM CAS, 2005

Complexity of Network Environment



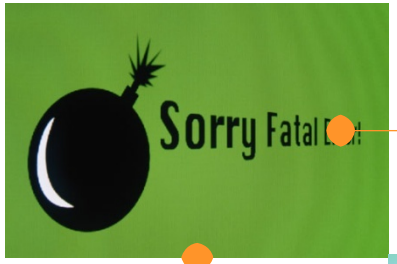
Growing Complexity



- Very large scales
  - Million of entities
- Amorphous structures/behaviors
  - P2P, bus, hierarchical architecture
- Dynamic
  - Entities join, leave, move, change behavior
- Heterogeneous
  - Capability, connectivity, reliability, guarantees, QoS
- Lack of common/complete knowledge
  - Types, availability, connectivity, protocols, semantics

Business Challenges

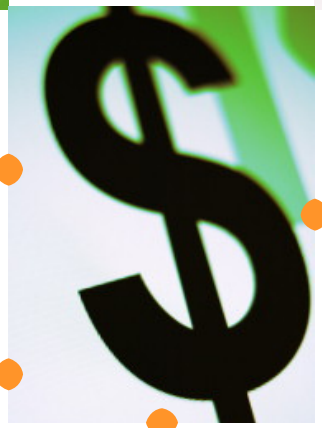
Up to 40% of today's outages result from operator errors



New applications get delayed by maintenance of diverse existing systems

Managing complex, heterogeneous environments

25-50% of time is spent on problem determination and resolution



Poorly documented legacy applications make it painful to diagnose and resolve complex cross-product problems

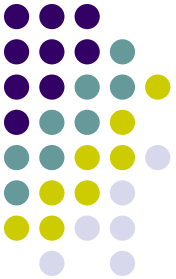
The skills needed to do manual cross-product problem determination are scarce and expensive

Outages of business-critical systems cost up to $2.8B per year

4 out of 5 IT dollars spent on operations, maintenance, and minor enhancements

Alan Ganek, VP IBM Autonomic Computing, 2003

The Complexity Problem



- The increasing **complexity of computing systems** is overwhelming the capabilities of software developers and system administrators to design, evaluate, integrate, and manage these systems
- Major software and system vendors have concluded that the only viable **long-term solution is to create computing systems that manage themselves**

… an elusive goal?!?

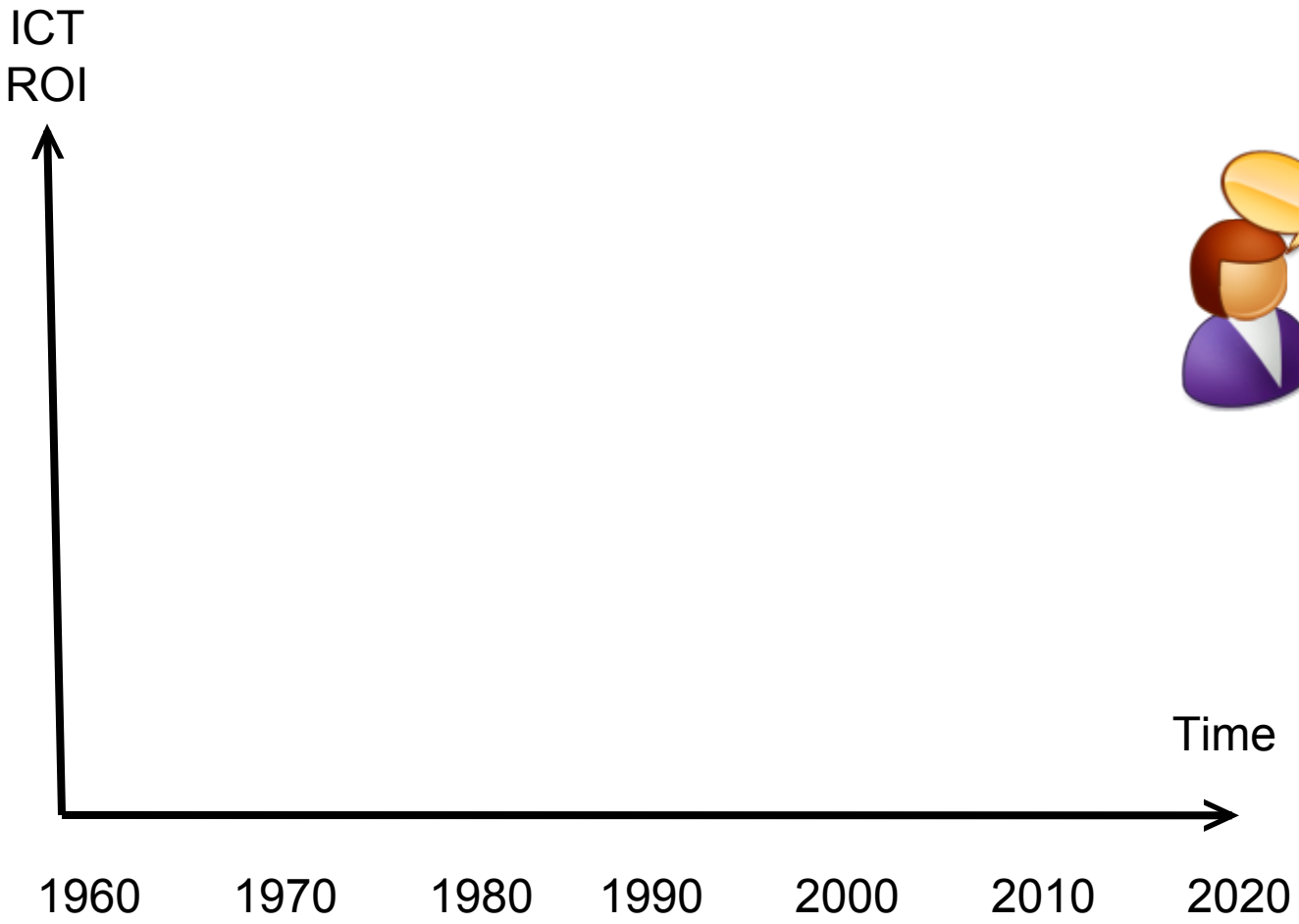
The Automation Conundrum

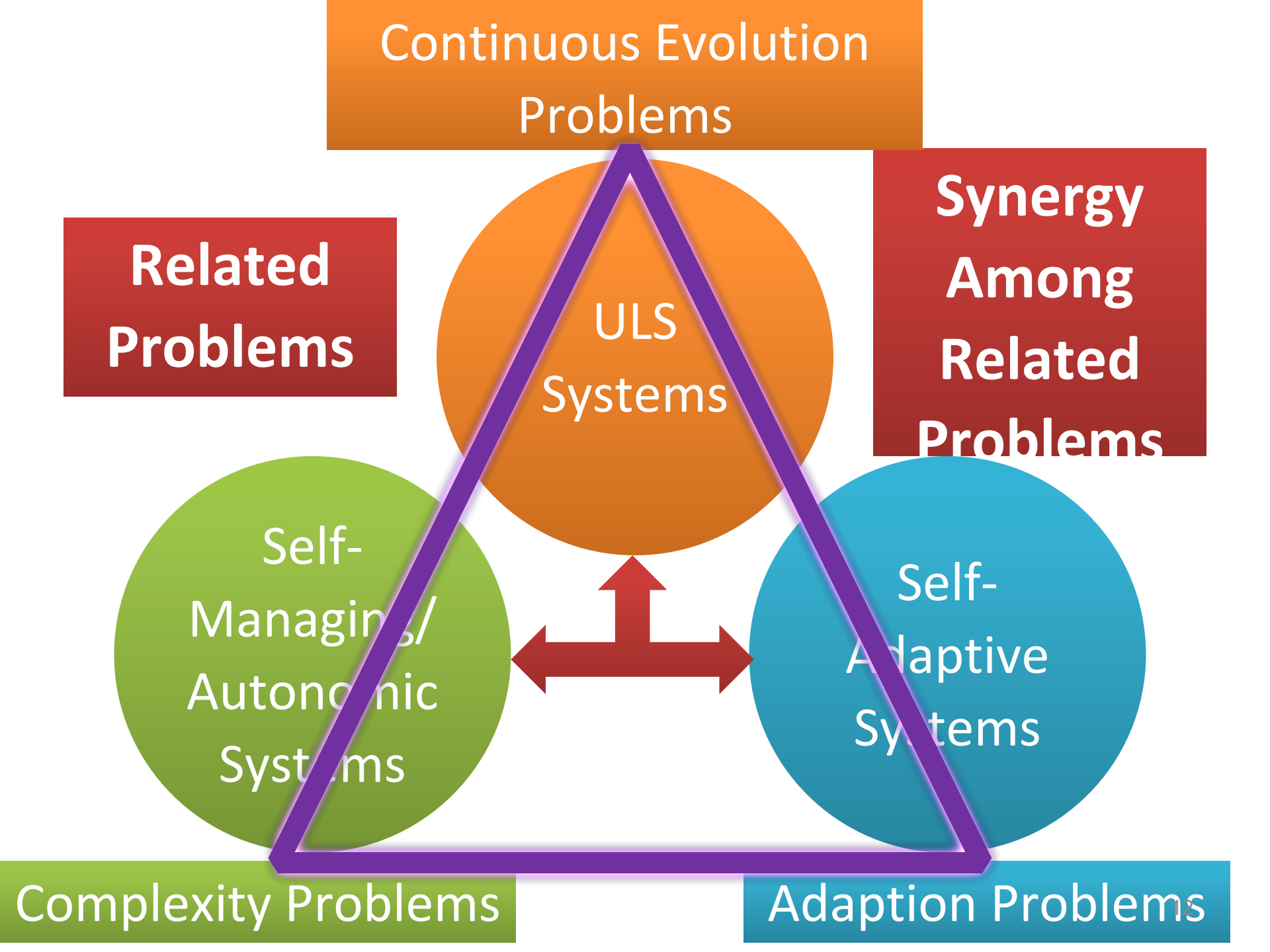
- Over the past 50 years, computer systems have had a huge capacity to automate
  - Enormous variety of tasks
  - Cost per task greatly reduced
  - Incalculable benefits
  - Unprecedented success

- Key challenges
  - Further declines in task costs by traditional methods are subject to the law of **diminishing returns**
  - The **complexity** of infrastructure management threatens to outweigh the benefits of further automation

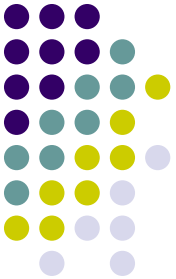
A. Spector, VP IBM Services and Software Research, 2003

ICT Return of Investment




Continuous Evolution Problems
Related Problems
Synergy Among Related Problems
ULS Systems
Self-Managing/ Autonomic Systems
Self-Adaptive Systems
Complexity Problems
Adaption Problems

The Complexity Problem



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… an elusive goal?!?

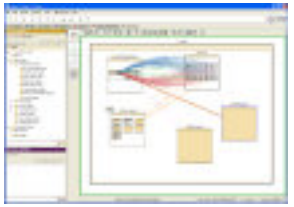
Categories of Complexity

- Algorithms & Data Structures
  - Time
  - Space

$$O(n \log n)$$

Development & Maintenance

- Logical
- Structural
- Comprehensibility

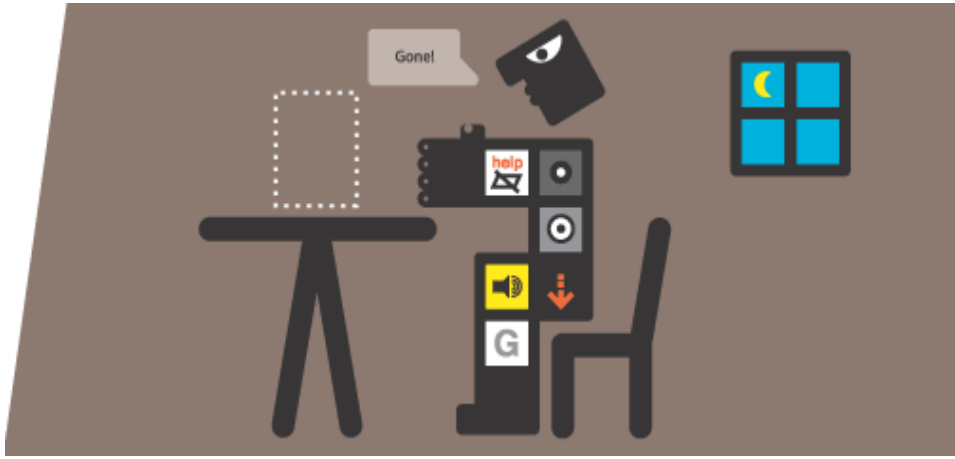


- Usage

	Novice	Average	Expert
Install			
Configure			
Administer			
Use			

The Conquest of Complexity

- There has never been anything quite like information technology before, but there have certainly been other complex technologies that needed simplifying
- To be truly successful, a complex technology needs to “disappear”



Source: A. Kluth: Information Technology. The Economist, Oct 28, 2004

19th Century Technology

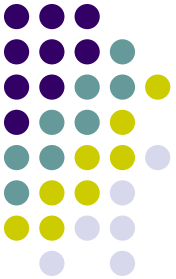
- Mechanical Clocks and Sewing machines
  - 1820's Long 40 page manuals of usage
  - 1880's Are simple and widely used
- Phonograph
  - Edison's 1877 cylinder version was unusable
  - Berliner's simplified disc version became gramophones, Victrolas, and record players

19th Century Technology

- Automobile
  - 1900s: mostly burden and challenge
    - Required skill in lubricating moving parts
    - Sending oil manually to the transmission
    - Frequent breakdowns
    - Mechanic hired as chauffeur
  - 1930s: usable and ready for mass market
    - Infrastucture: roads, gas stations, repair shops
    - Hiding technology from drivers
    - Highly more complex on the inside, because most of the tasks that had previously been carried out by drivers now had to be done automatically
    - Greatly simplified interface, more reliable

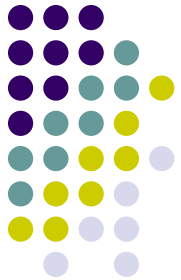
Model T Ford

20th Century Technology



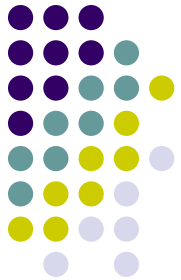
- Electricity and power distribution
  - First generation
    - Households and firms have own generators
    - Full time job to keep the generators going
    - Vice President of Electricity (VPE)
      - like CIO or CTO today
  - Only one generation later
    - Power grid
    - Simplified, ubiquitous power plug
    - VPE disappeared
      - will CIOs or CTOs disappear?

Predictable Path of Technology



- Early stages
  - Technology needs lots of human involvment
  - New inventions are typically “geeky”, requiring significant expertise to install and maintain
  - In general, the “default” seems to be human work, due to its flexibility and adaptivity
  - At an early stage human involvement is always superior to alternatives
  - Culling of features is futile
- Push the complexity to the back end to make the front end very simple
  - Consumers don’t know when the Power Company upgrades its technology

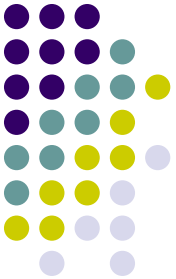
Predictable Path of Technology



- Mature stage
  - Need for human expertise is greatly reduced due to technology becoming simple and standardized
  - To increase adoption and sales (electricity, cars)
  - To decrease cost (industrial revolution, agriculture)
  - To allow super-human performance (space aviation)
- Simplicity of usage often means increased overall system complexity
  - For every mouse click we take out of the user experience, 20 things have to happen in the software behind the scenes

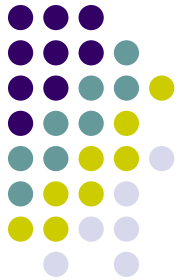
Given this historical perspective, maybe there is hope for the information technology sector?!

Grand Challenge



- Today's computing systems are amazingly complex, and require daunting expertise and patience just to get them running and keep them running
- The increasing system administration will become a major barrier to deploying and maintaining large computing systems

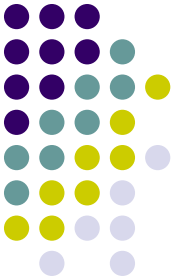
No Shortage of Complexity Industry Conquest Solutions



HP	Adaptive enterprise using OpenView
IBM	Autonomic computing
EDS	Agile enterprise
Hitachi	Harmonius computing
Sun	N1
Dell	Dynamic computing
MS	Dynamic systems initiative

Industry's efforts to emulate Nature's Gold Standard of ***virtualization software*** *and* ***complexity concealment***

Autonomic Computing Vision

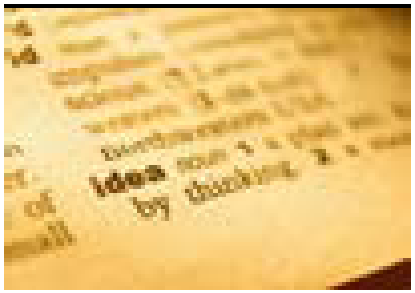


Autonomic Computing is really about making systems self-managing …

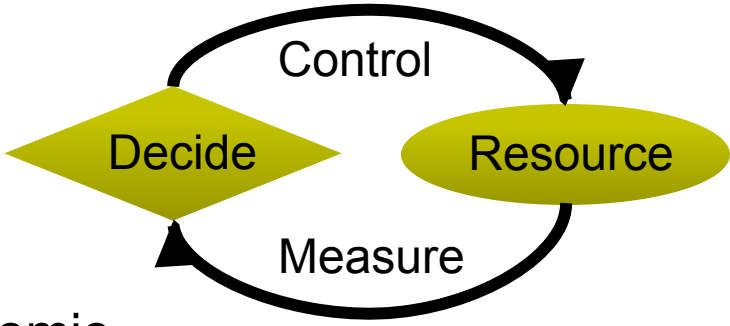
—Paul Horn, IBM Research, 2001

What is Autonomic Computing?

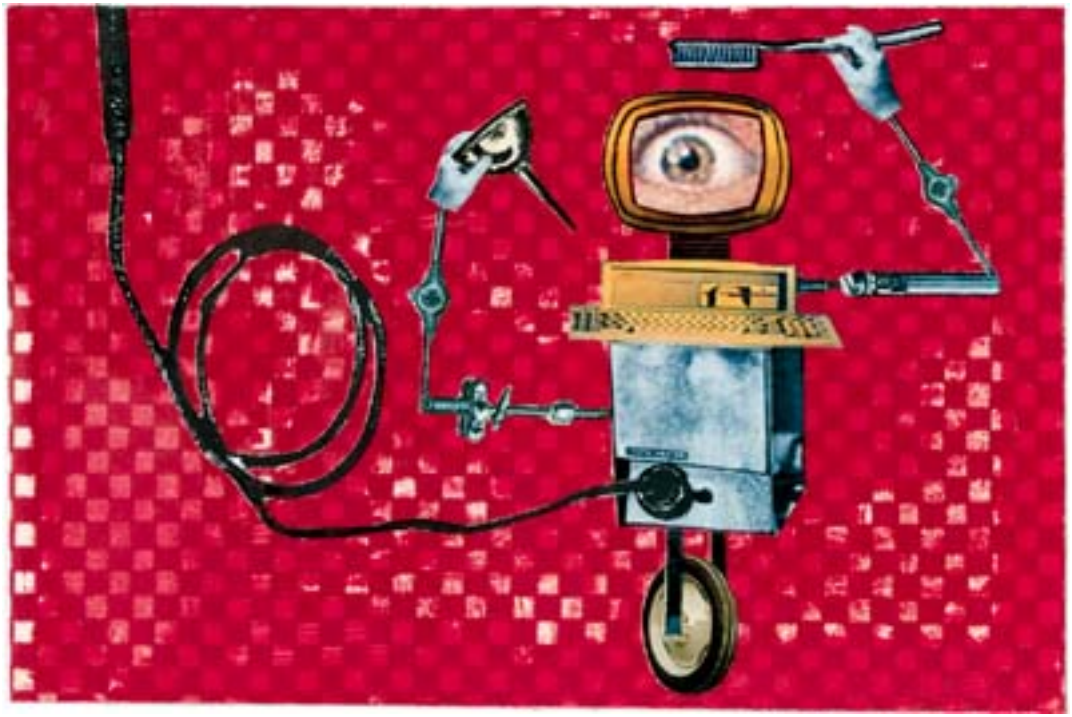
- Webster's definition
  - Acting or occurring involuntarily; automatic: an autonomic reflex
  - Relating to, affecting, or controlled by the autonomic nervous system or its effects or activity
  - Autonomic nervous system: that part of the nervous system that governs involuntary body functions like respiration and heart rate



- IBM's definition
  - An approach to self-managed computing systems with a minimum of human interference
  - The term derives from the body's autonomic nervous system, which controls key functions without conscious awareness or involvement



A First Look at an Autonomic System

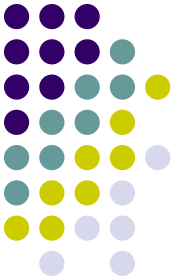


Autonomic System = Self-Managing System

Reading Assignment

- Kephart & Chess; IEEE Computer, 36(1):41-50, Jan 2003
- IBM: An Architectural Blueprint for Autonomic Computing, 4th Ed., 2006

To Explore Further Conferences and Journals



TASS	ACM Transactions on Autonomous and Adaptive Systems (TAAS)
ICAC	IEEE International Conference on Autonomic Computing
SASO	Self-Adaptive and Self-Organizing Systems
SEAMS	Software Engineering for Adaptive and Self-Managing Systems
CASCON	Workshop on Engineering Self-Managing Systems: Research and Practice
WOSS	Workshop on Self-Healing Systems
DEAS	Design and Evolution of Autonomic Application Software