Emerging Technologies for Software-Reliant Systems

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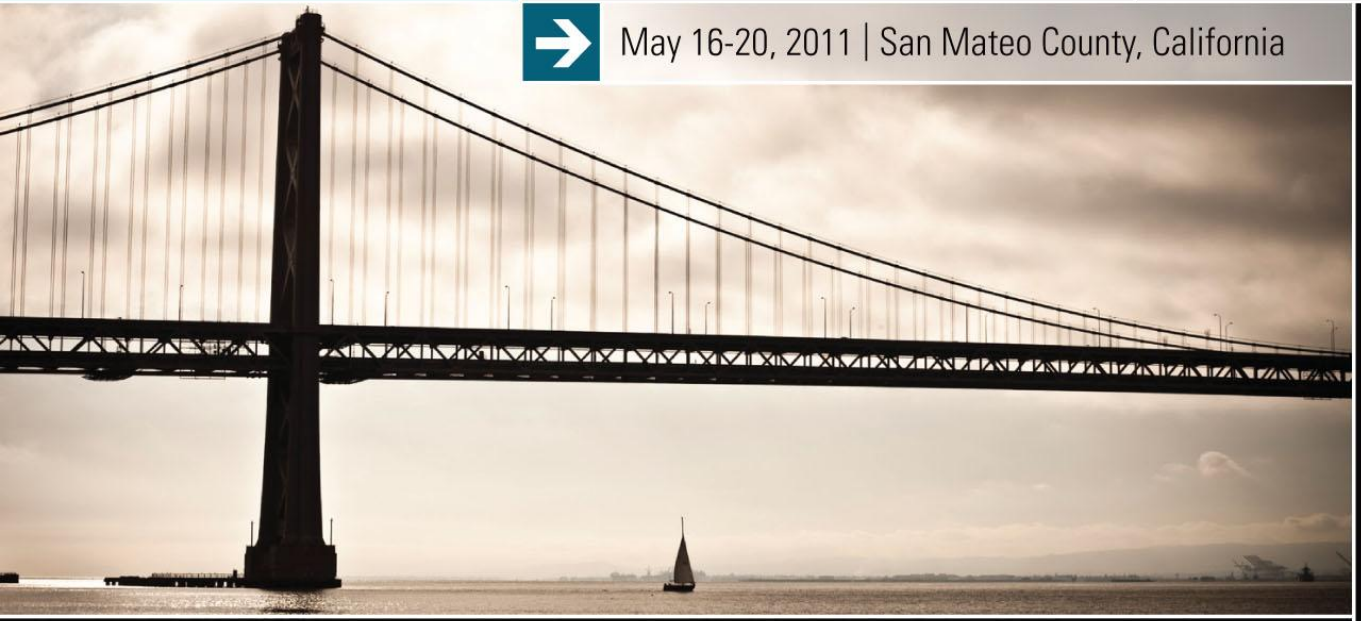

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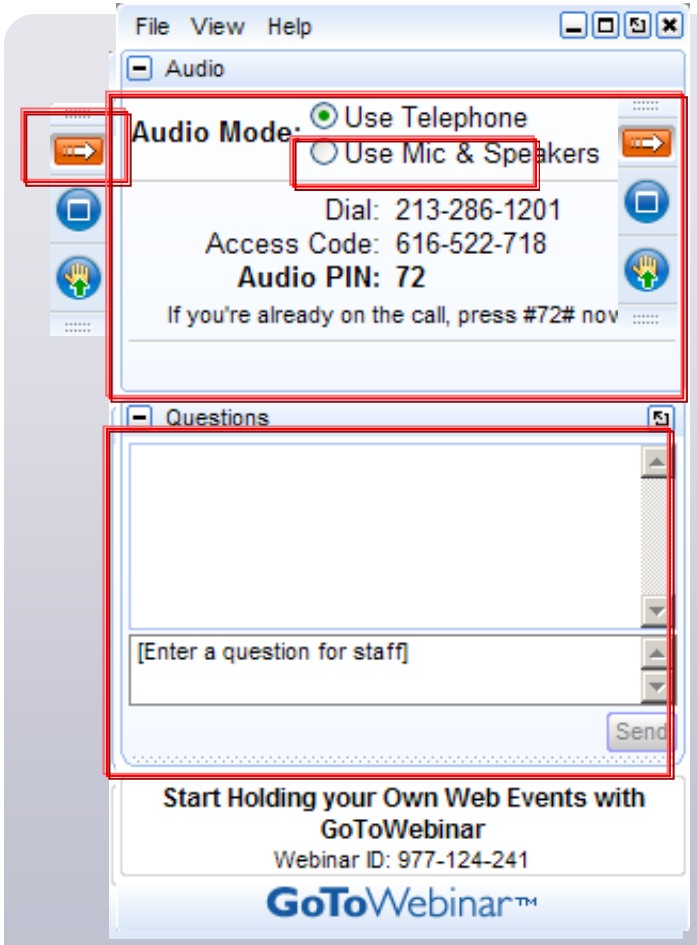


Open and close your Panel

View, Select, and Test your audio

Submit text questions

Q&A addressed at the end of today's session

Today's Speaker

Grace Lewis is a Senior Member of the Technical Staff at the Software Engineering Institute (SEI) within the Systems of Systems Practice (SoSP) initiative in the Research, Technology and Systems Solutions (RTSS) program. Her current interests and projects are in service-oriented architecture (SOA), cloud computing, context-aware applications and technologies for systems interoperability. Her latest publications include multiples reports and articles on these subjects and a book in the SEI Software Engineering Series. She is also a member of the technical faculty for the Master in Software Engineering program at Carnegie Mellon University (CMU). Grace holds a B.Sc. in Systems Engineering and an Executive MBA from Icesi University in Cali, Colombia; and a Master in Software Engineering from CMU.

Polling Question

What emerging technology do you think will have the most impact on your organization ?

1. Cloud Computing
2. Mobile Computing
3. Social Computing
4. Data Intelligence
5. Not Sure

General Computing Trends

Several trends are shaping the way that organizations are building systems to support their business and operational needs

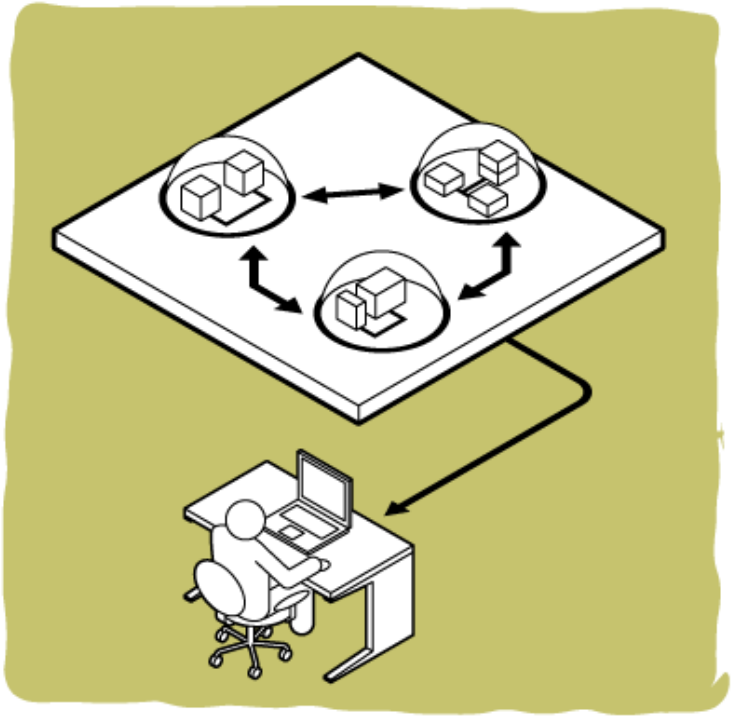
- Loose coupling
- Global distribution of hardware, software and people
- Horizontal integration and convergence
- Virtualization
- Commoditization of technology
- End-user empowerment
- Large-scale data mining
- Low energy consumption
- Multi-core and parallelization

Loose Coupling

Coupling is the degree to which a system element relies on other system elements to perform its tasks.

Push for two types of loose coupling

- between capabilities and consumers of those capabilities to ease integration
- between system elements that contain capabilities and the interfaces exposed to consumers of those capabilities such that implementation details are hidden from consumers



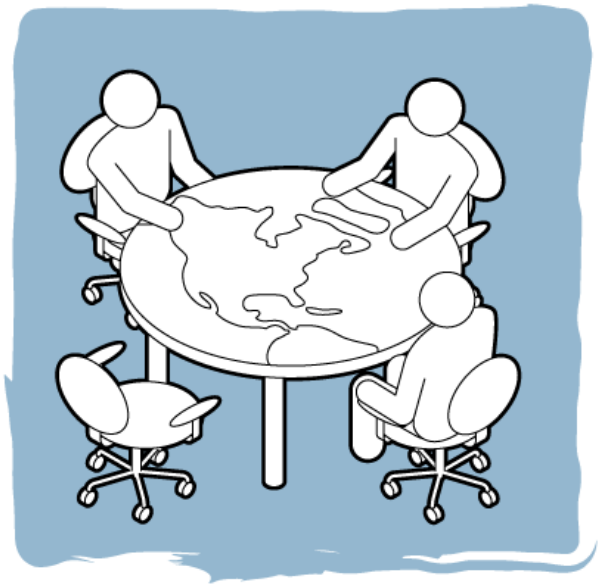
Implication

Standardization of capability interfaces as well as ways to describe those capabilities

Global Distribution of Hardware, Software and People

Globalization is an essential part of software systems in many ways

- Software systems are often built by multinational teams
- Many organizations use offshoring as a way to reduce costs of software development
- Large web-based systems often use distributed caching services for better response times



Implication

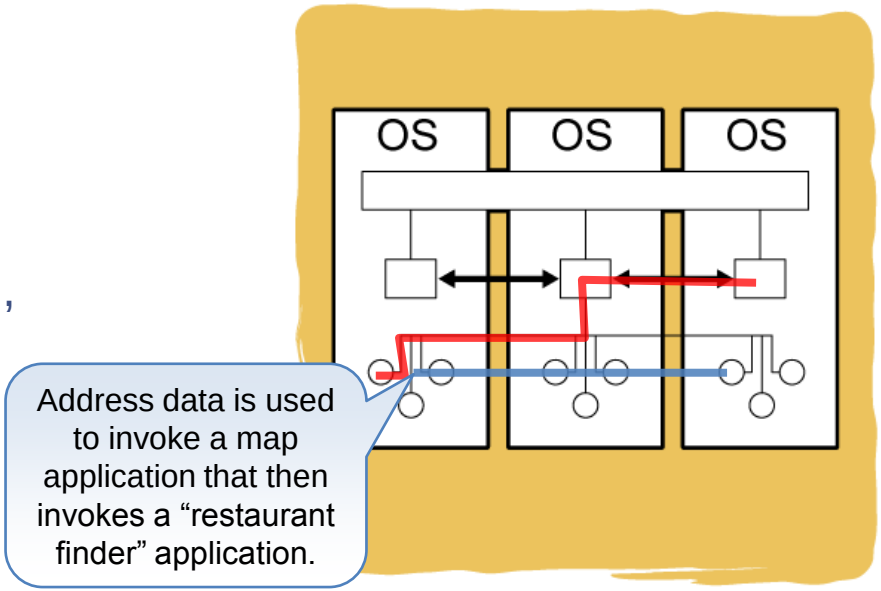
Greater coordination of distributed hardware, software, and people—as well as better technologies for fault detection and recovery in distributed systems

Horizontal Integration and Convergence

Move from vertical to horizontal integration

- Vertical integration — single manufacturer controls platform, middleware, and applications, bundling them into solutions for delivery to customers
- Horizontal integration — applications are expected to run on any middleware and middleware is expected to run on any platform

In addition, applications are expected to exchange data seamlessly



Implication

Exposure of APIs at the middleware and platform levels in ways that permit developers to enable horizontal integration and convergence

Virtualization

Virtualization in general is the abstraction of computing resources

- Network virtualization
- Storage virtualization
- Server virtualization

Server and storage virtualization are mostly adopted as an IT cost-savings strategy

Network virtualization is used mostly for easier network management but also IT savings

Implication

Use of efficient virtualization strategies as well as improved resource hiding and interfaces to virtualized resources

Commoditization of Technology

The price of technology is decreasing to a point that technology is ubiquitous

Because of commoditization, it is becoming difficult for technology vendors to differentiate their products or to hold large market shares for a long period of time

Technology vendors have to add value through customizing their products or create new products to continually differentiate themselves from their competitors

Implication

Systems have to be built in a way that minimizes the impact of changing technologies while making them accessible from a wide variety of devices

End-User Empowerment

Because of technology commoditization, end users are more competent with technology.

End users want technologies that will help them get access to information without having to wait for developers to create the proper programs and reports.

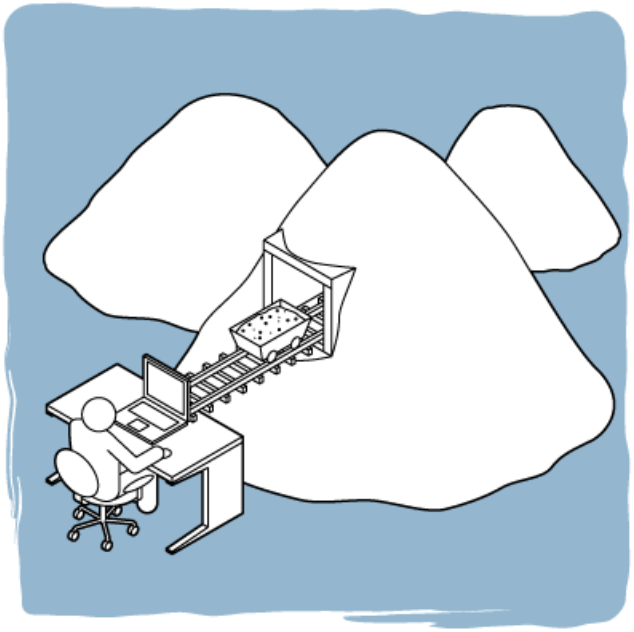
Implication

Awareness of what end users can and want to do, even if they have not been trained as software developers

Large-Scale Data Mining

Data is everywhere.

There is more and more data to analyze, process, and transform into useful information in real time.



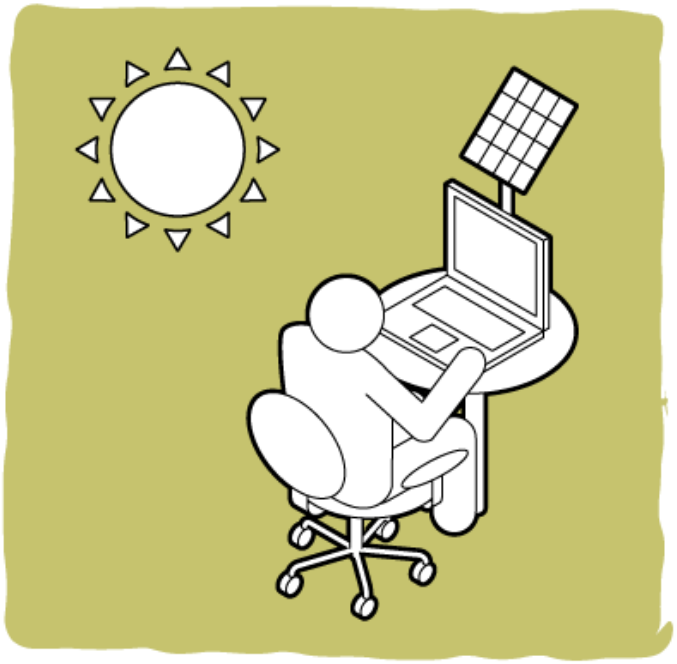
Implication

More efficient algorithms for pre-processing, processing, clustering, and analyzing large amounts of data, as well as the proper storage and computation power to do this in near real time.

Use of data structures more efficient than relational databases

Low Energy Consumption

Driven by environmental concerns as well as the increased computing power in handheld devices



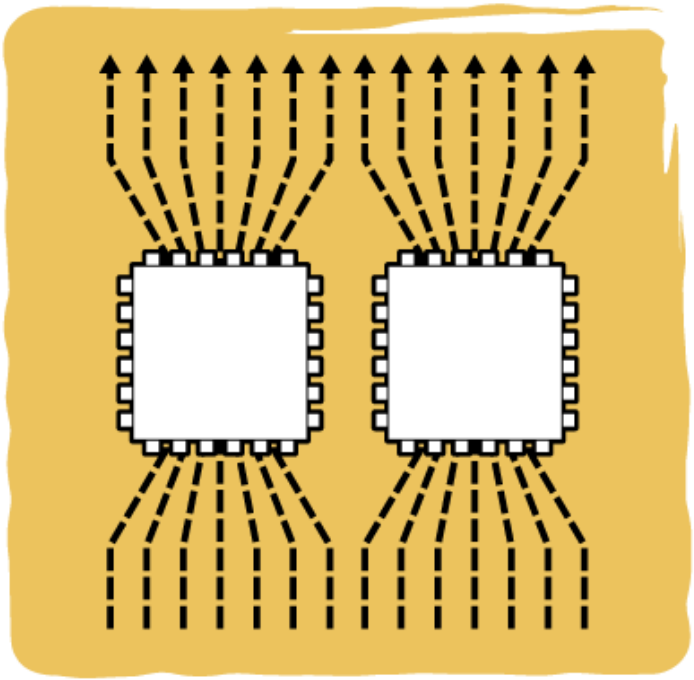
Implication

More research in energy efficiency, extending into algorithms and software that demand fewer computational cycles or take better advantage of existing computational resources

Multi-Core and Parallelization

Multi-core processors have two or more independent cores in order to process multiple instructions in parallel

However, the performance gained by use of multi-core processors highly depends on software algorithms and implementation that can be parallelized.



Implication

Better software algorithms and implementation that can take advantage of having multiple cores

Technologies Supporting General Trends

Cloud Computing

Complex Event Processing (CEP)

Data Intelligence

End-User Programming (EUP)

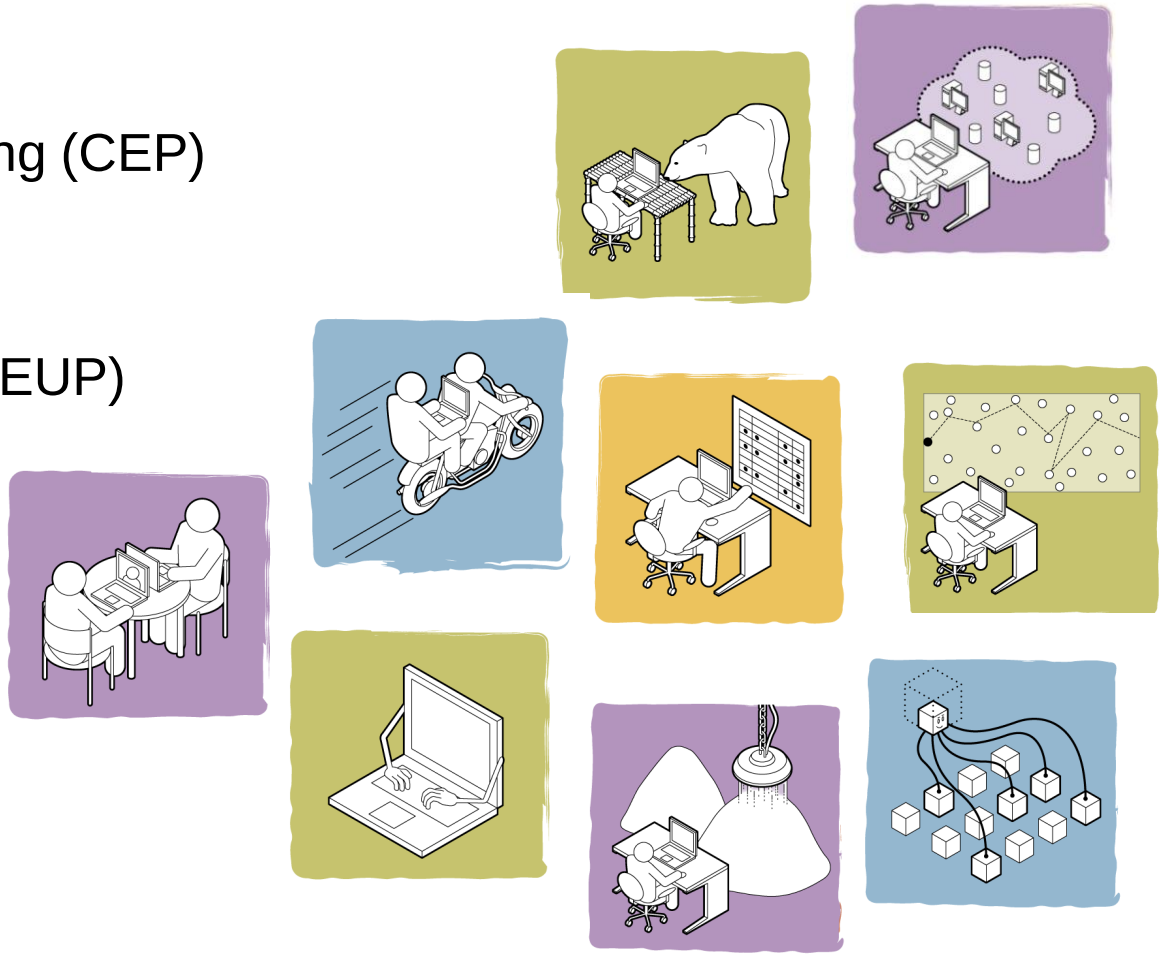
Green Computing

Mobile Computing

Opportunistic Networks

Self-*Computing

Social Computing



Cloud Computing

Distributed computing paradigm that focuses on providing users with access to scalable, virtualized hardware or software infrastructure over the internet

- Infrastructure-as-a-Service (IaaS): Computational infrastructure available over the internet, such as compute cycles and storage, which can be utilized in the same way as internally owned resources
- Platform-as-a-Services (PaaS): application development platforms—hardware and software components—that enable developers to leverage the resources of established organizations to create and host applications of a larger scale than an individual or small organization would be able to handle
- Software-as-a-Service (SaaS): business-specific that are licensed to customers for use as a service on demand

Related terms and technologies: grid computing, utility computing, on-demand computing, containerized data centers

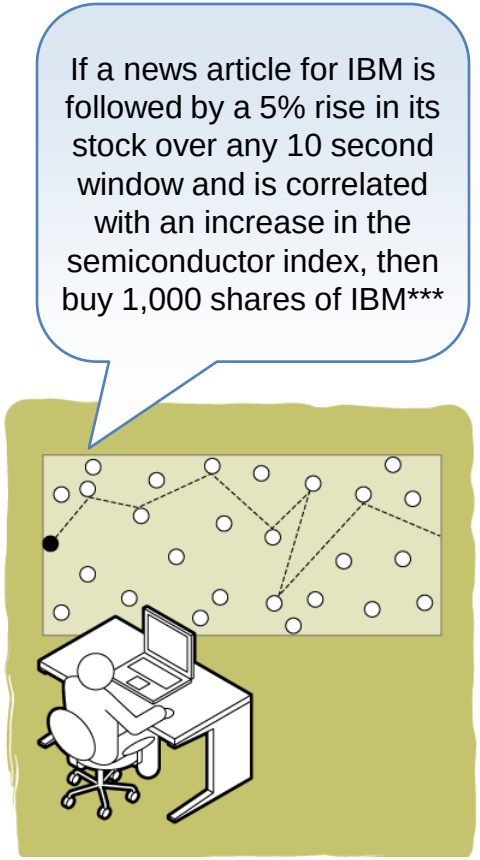
Complex Event Processing (CEP)

Special form of event processing which operates on complex events.

- A complex event is “an event that is an abstraction of other events called its members”*
- Complex events are composed or derived from a set of events related by time, causality, abstraction, or other relationships.

CEP systems find patterns in events to detect certain business opportunities or threats**

Related terms and technologies: Event-Driven Architecture (EDA) and Event Stream Processing (ESP)



* David Luckham and Roy Schulte (editors). Event Processing Glossary - Version 1.1. Event Processing Technical Society. 2008. http://complexevents.com/wp-content/uploads/2008/08/epts-glossary-v11.pdf

** K. Mani Chandy and Roy Schulte, “The Role of Event Processing in Modern Business”, ebizQ, 2007, http://www.ebizq.net/hot_topics/cep/features/8303.html?page=1

*** Example extracted from progesssoftware.com

Data Intelligence

Mining, aggregation, fusion, selection, search, and exploitation of huge volumes of disparate data coming from diverse sources

- Databases, sensor networks, human observation, human judgment, RSS feeds, GPS data, …

Just as information is considered to be a “step ahead” of simply data, the end goal of data intelligence is knowledge—the next step.

Relies on large-scale data mining in which large amounts of heterogeneous, raw data goes thorough a pre-processing stage, a transformation stage and finally a pattern recognition stage that produces knowledge.

Related terms: Information Superiority and MapReduce*

* http://www.mapreduce.org/

End-User Programming

The practice where end users write computer programs to satisfy a specific need, where the end-user programmers have not necessarily been taught how to write code in conventional programming languages, e.g. Excel spreadsheets and high-level scripting.*

Related terms and technologies: Intentional Programming**, Edge Programming***, Gesture Programming****

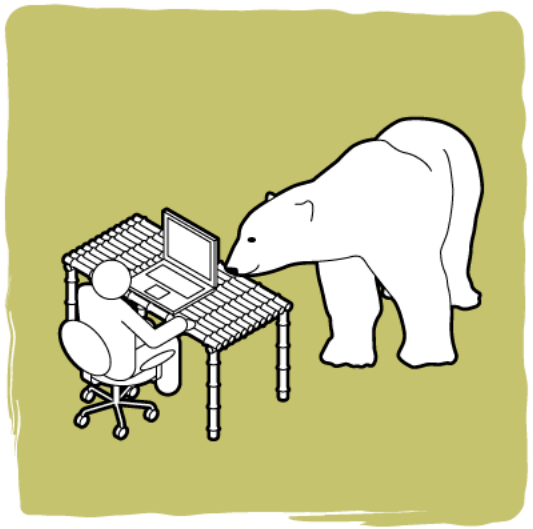
* http://eusesconsortium.org/
** http://www.intentsoft.com/
*** K. Sullivan, Edge Programming, http://www.cs.virginia.edu/~sullivan/ULS1/ULS07/sullivan.pdf
**** R. Voyles, Gesture-Based Programming, http://www-users.cs.umn.edu/~voyles/research.gesture.html

Green Computing

Green computing refers to "the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems—such as monitors, printers, storage devices, and networking and communications systems—efficiently and effectively with minimal or no impact on the environment."*

Software-related "green practices"

- Algorithmic efficiency
- Platform virtualization
- Terminal servers (thin clients)



Related terms: Energy-Efficient Computing, Smart Grid**

* S. Murugesan, "Harnessing Green IT: Principles and Practices," IEEE IT Professional, January-February 2008, pp 24-33.

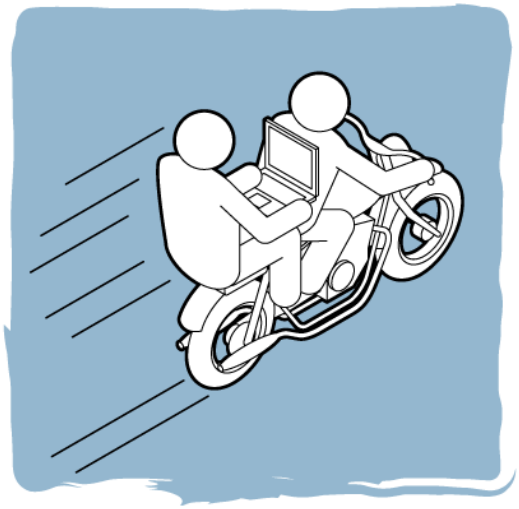
** Smart Grid. http://en.wikipedia.org/wiki/Smart_grid

Mobile Computing

Generic term that describes the possibility to use computing technology “on the go” through devices such as SmartPhones, PDAs (personal digital assistants), portable computers, and wearable computers

Mobile users expect seamless access to information anytime, anywhere, and from any device

Related terms and technologies: location-based services, physical computing

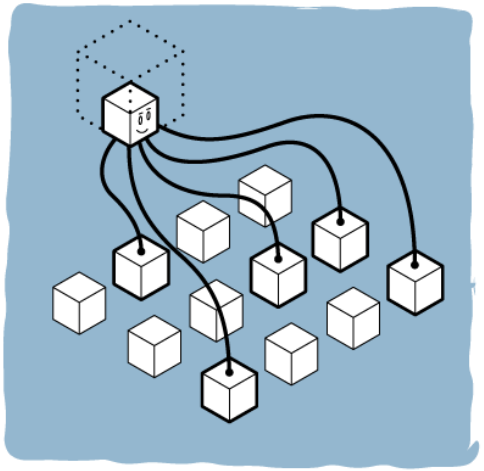


Opportunistic Networks (Oppnets)

Initially, a relatively small seed oppnet is deployed, which grows into a bigger expanded oppnet.*

Oppnet growth starts with detecting diverse systems existing in its relative vicinity.

Systems with best evaluations are invited by an oppnet to become its helpers.



The oppnet leverages vast collective capabilities and resources of its helpers, employing them to execute diverse tasks in support of its goals.

Related terms and technologies: Mobile Ad-Hoc Networks (MANETs), VANETs (Vehicular Ad-Hoc Networks), Mesh Networks, Unstructured Peer-to-Peer (P2P) Systems, Wireless Sensor Networks**, Cognitive Networks***

* Lilien et al. Opportunistic Networks: Challenges in Specializing the P2P Paradigm. http://www2.computer.org/portal/web/csdl/doi/10.1109/DEXA.2006.107
** Conti et al. Multihop Ad Hoc Networking: The Reality. IEEE Communications Magazine. April 2007.
*** Qusay at al. Cognitive Networks: Towards Self-Aware Networks", Ed., Wiley, 2007.

Self-* Computing

Systems that are aware of their environment and adaptable to changing characteristics of the environment

- Self-adaptation
- Self-awareness
- Self-configuration and reconfiguration
- Self-healing
- Self-knowledge of components
- Self-optimization
- Self-protection

Related terms and technologies: Autonomic Computing*, Biomimetics**, Sociomimetics***

* IBM Research: Autonomic Computing, http://www.research.ibm.com/autonomic/
** Y. Bar-Cohen. Biomimetics: Biologically Inspired Technologies. CRC Press. 2006
*** http://www.trampolinesystems.com/

Social Computing

General term for an area of computer science that is concerned with the intersection of social behavior and computational systems*, **

Wide range of examples of social computing

- Social software: wikis, blogs , RSS, collaboration tools, social networking
- Socially-inspired computation: collaborative filtering, online auctions, prediction markets, reputation systems, computational social choice and social tagging

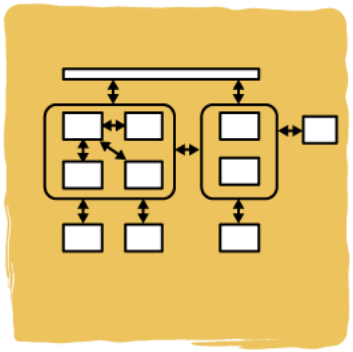
Related technologies: Enterprise 2.0***, social information processing****

* Social Computing. http://en.wikipedia.org/wiki/Social_computing
** NSF Proposal Solicitation: http://www.nsf.gov/pubs/2009/nsf09559/nsf09559.htm
*** "What is Web 2.0?". Association for Information and Image Management. 2008. http://www.aiim.org/What-is-Web-2.0.aspx.
**** Social Information Processing Symposium. http://www.isi.edu/~lerman/sss07/

Required Software Engineering Emphasis Due to Emerging Technologies (1)

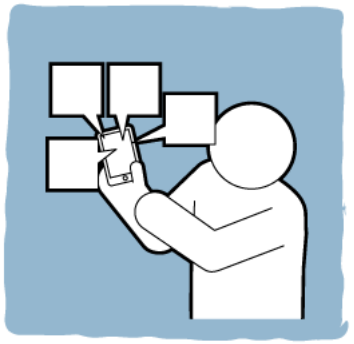
Software Architecture

- Quality attribute characterization
- Model analyses



Mobile Applications

- Resource optimization
- Technology adaptation
- Integration with business systems and the cloud
- Security



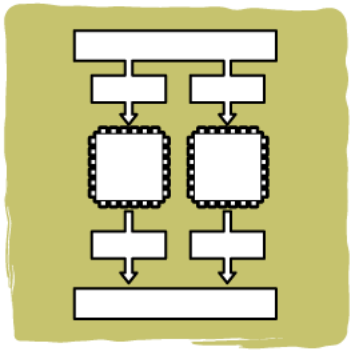
Required Software Engineering Emphasis Due to Emerging Technologies (2)

Defensive Programming

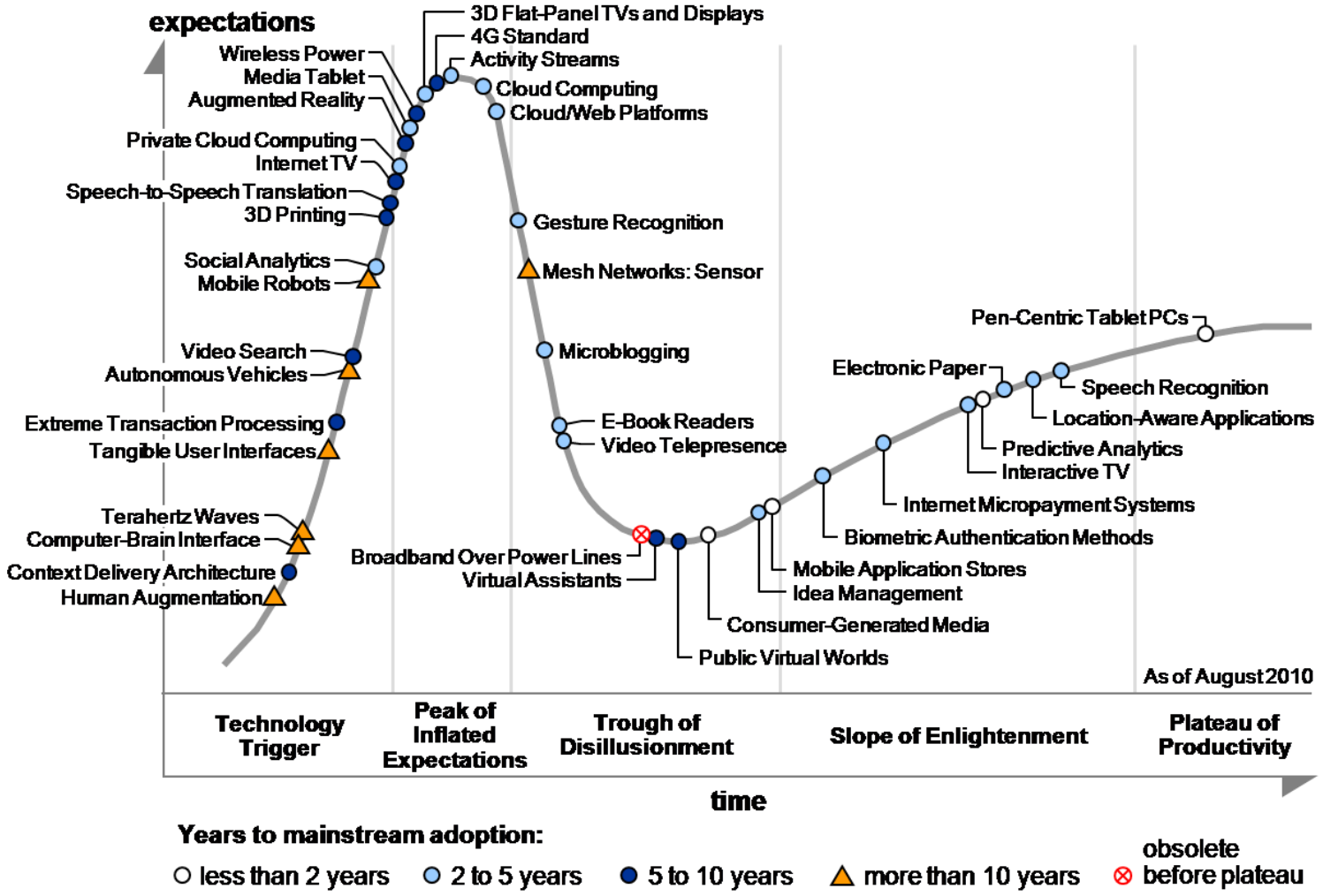
- Security
- Auto-adaptation
- Globalization
- Exception handling due to lack of control over all system elements

Parallel Programming

- Multiple processors
- MapReduce (Hadoop)
- Resource optimization



Technologies Follow "Hype Cycles"



Source: Gartner, Hype Cycle for Emerging Technologies, 2010

For More Information

Emerging Technologies for Software-Reliant Systems of Systems

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September 2010

http://www.sei.cmu.edu/library/abstracts/reports/10tn019.cfm

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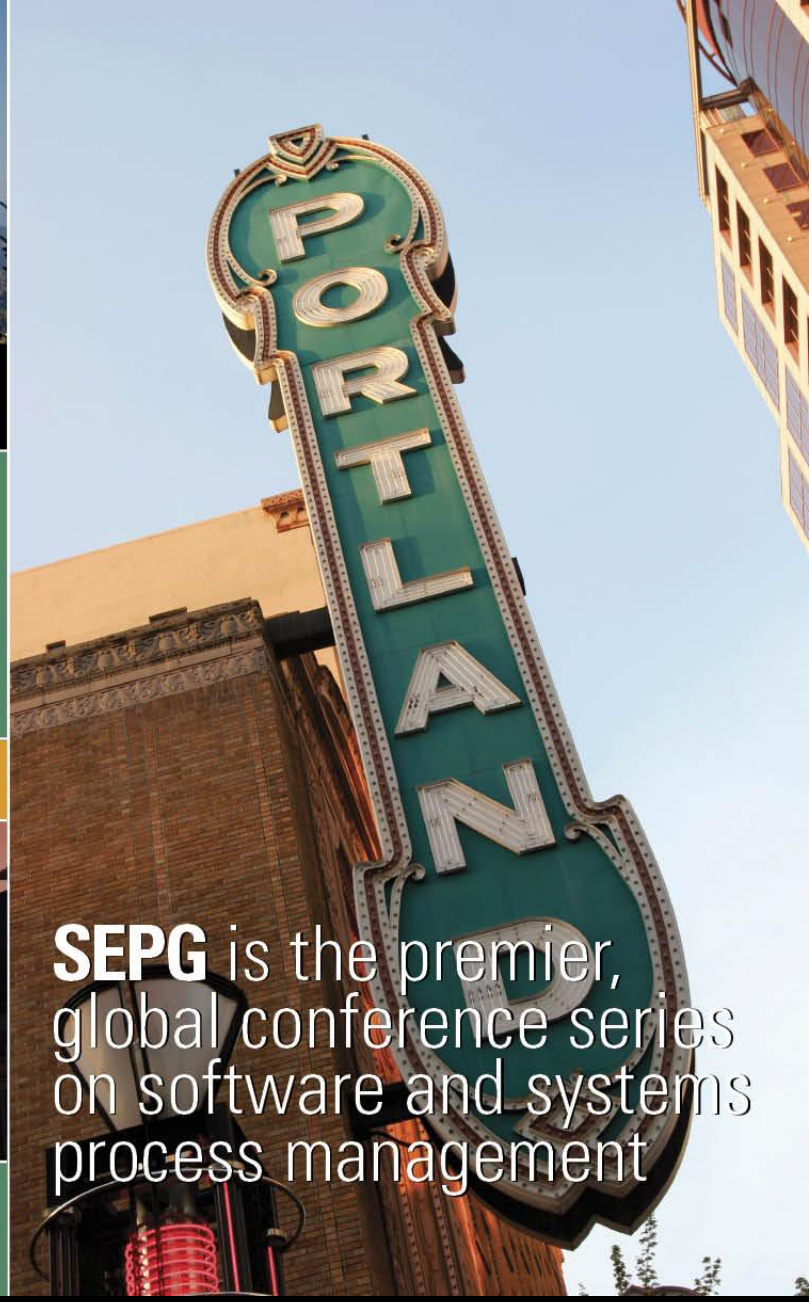

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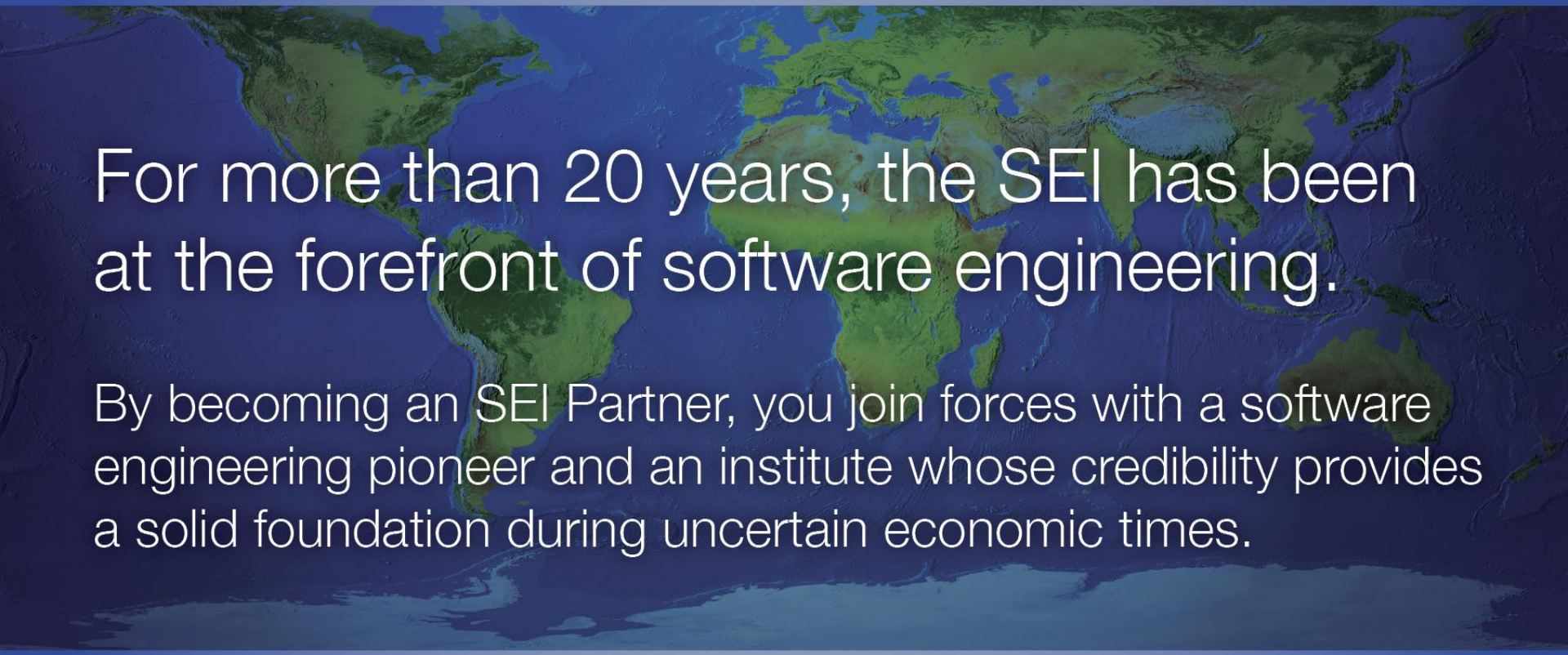

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