X-Informatics
Cloud Technology Part I: Introduction

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http://www.infomall.org/X-InformaticsSpring2013/index.html

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2013

Big Data Ecosystem in One Sentence

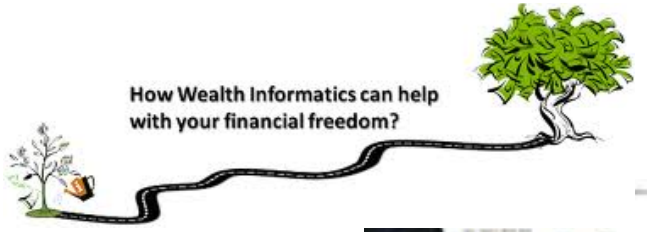
Use Clouds running Data Analytics processing Big Data to solve problems in X-Informatics (or e-X)

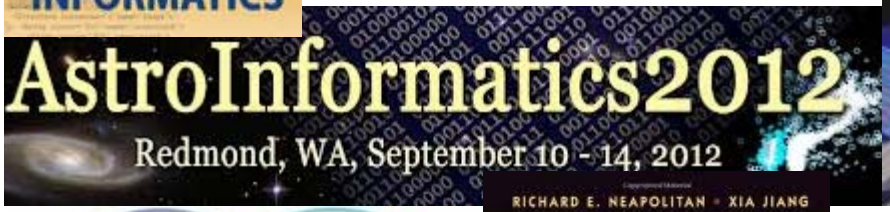
X = Astronomy, Biology, Biomedicine, Business, Chemistry, Crisis, Earth Science, Energy, Environment, Finance, Health, Intelligence, Lifestyle, Marketing, Medicine, Pathology, Policy, Radar, Security, Sensor, Social, Sustainability, Wealth and Wellness with more fields (physics) defined implicitly

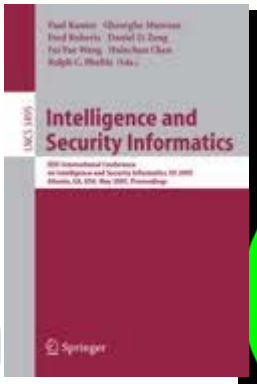
Spans Industry and Science (research)

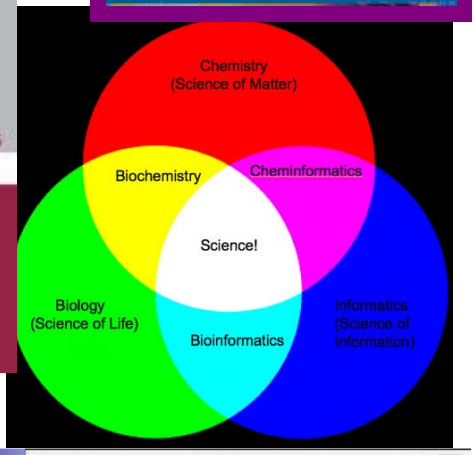
Education: Data Science see recent New York Times articles

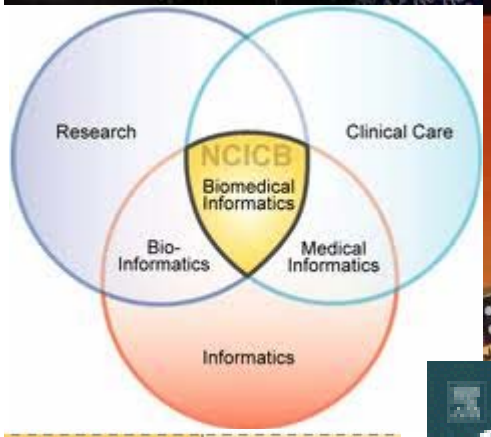
http://datascience101.wordpress.com/2013/04/13/new-york-times-data-science-articles/

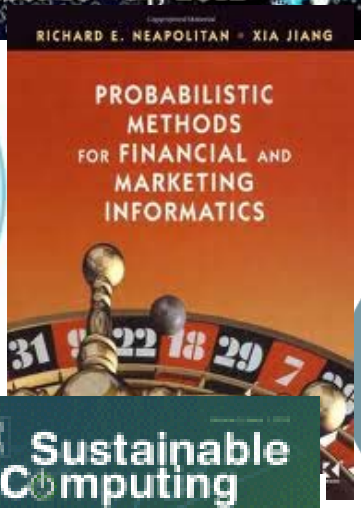


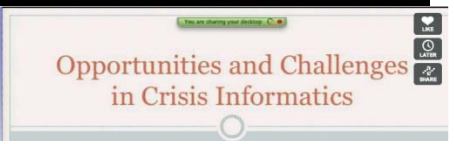


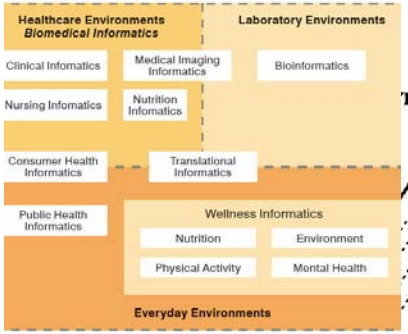


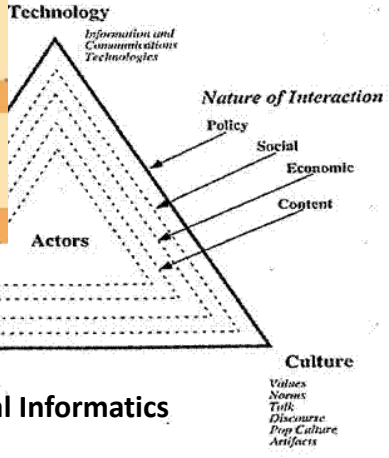




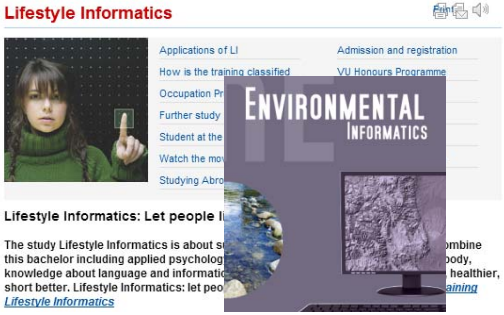








Social Informatics



Cyberinfrastructure for e-moreorlessanything or moreorlessanything-Informatics

What is Cyberinfrastructure

- Cyberinfrastructure is (from NSF) infrastructure that supports distributed research and learning (e-Science, e-Research, e-Education)
  - Links data, people, computers
- Exploits Internet technology (Web2.0 and Clouds) adding (via Grid technology) management, security, supercomputers etc.
- It has three aspects: parallel – low latency (microseconds) between nodes and distributed – highish latency (milliseconds) between nodes while clouds in between
- Parallel needed to get high performance on individual large simulations, data analysis etc.; must decompose problem
- Distributed aspect integrates already distinct components – especially natural for data (as in biology databases etc.)

e-moreorlessanything

- ‘e-Science is about global collaboration in key areas of science, and the next generation of infrastructure that will enable it.’ from inventor of term John Taylor Director General of Research Councils UK, Office of Science and Technology
- e-Science or Science-Informatics is about developing tools and technologies that allow scientists to do ‘faster, better or different’ research
- Similarly e-Business captures the emerging view of corporations as dynamic virtual organizations linking employees, customers and stakeholders across the world.
- This generalizes to e-moreorlessanything or moreorlessanything-Informatics including e-DigitalLibrary, e-SocialScience, e-LifeStyle and e-Education
- A deluge of data of unprecedented and inevitable size must be managed and understood.
- People (virtual organizations), computers, data (including sensors and instruments) must be linked via hardware and software networks

What is Cloud Computing

Introduction

Physically Clouds are Clear

- A bunch of computers in an efficient data center with an excellent Internet connection
- They were produced to meet need of public-facing Web 2.0 e-Commerce/Social Networking sites
- They can be considered as “optimal giant data center” plus internet connection
- Note enterprises use private clouds that are giant data centers but not optimized for Internet access

Virtualization made several things more convenient

- Virtualization = abstraction; run a job – you know not where
- Virtualization = use hypervisor to support “images”
  - Allows you to define complete job as an “image” – OS + application
- Efficient packing of multiple applications into one server as they don’t interfere (much) with each other if in different virtual machines;
- They interfere if put as two jobs in same machine as for example must have same OS and same OS services
- Also security model between VM’s more robust than between processes

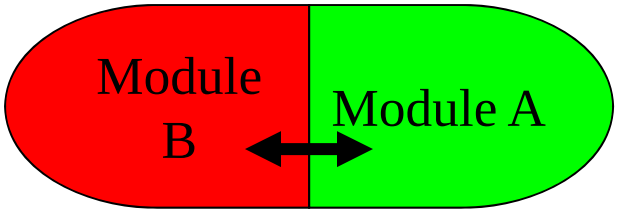
Next Step is Renting out Idle Clouds

- Amazon noted it could rent out its idle machines
- Use virtualization for maximum efficiency and security
- If cloud bigger enough, one gets elasticity – namely you can rent as much as you want except perhaps at peak times
- This assumes machine hardware quite cheap and can keep some in reserve
  - 10% of 100,000 servers is 10,000 servers
- I don't know if Amazon switches off spare computers and powers up on "mothers day"
  - Illustrates difficulties in studying field – proprietary secrets

Service Model

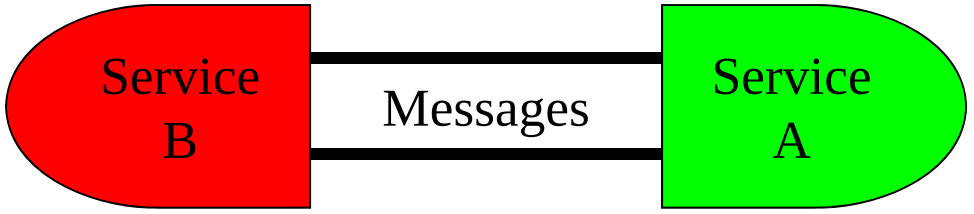
- This generalizes the Web where every site gobbles up commands from client and returns something – which could be quite complicated
- Generalization is "Service Oriented Architecture"
  - Everything has an interface that accepts information – in general from another service but perhaps from a client
  - Everything spits out information to where instructed to send

Closely coupled Java/Python Methods . . .



Method Calls
.001 to 1 millisecond

Coarse Grain Service Model

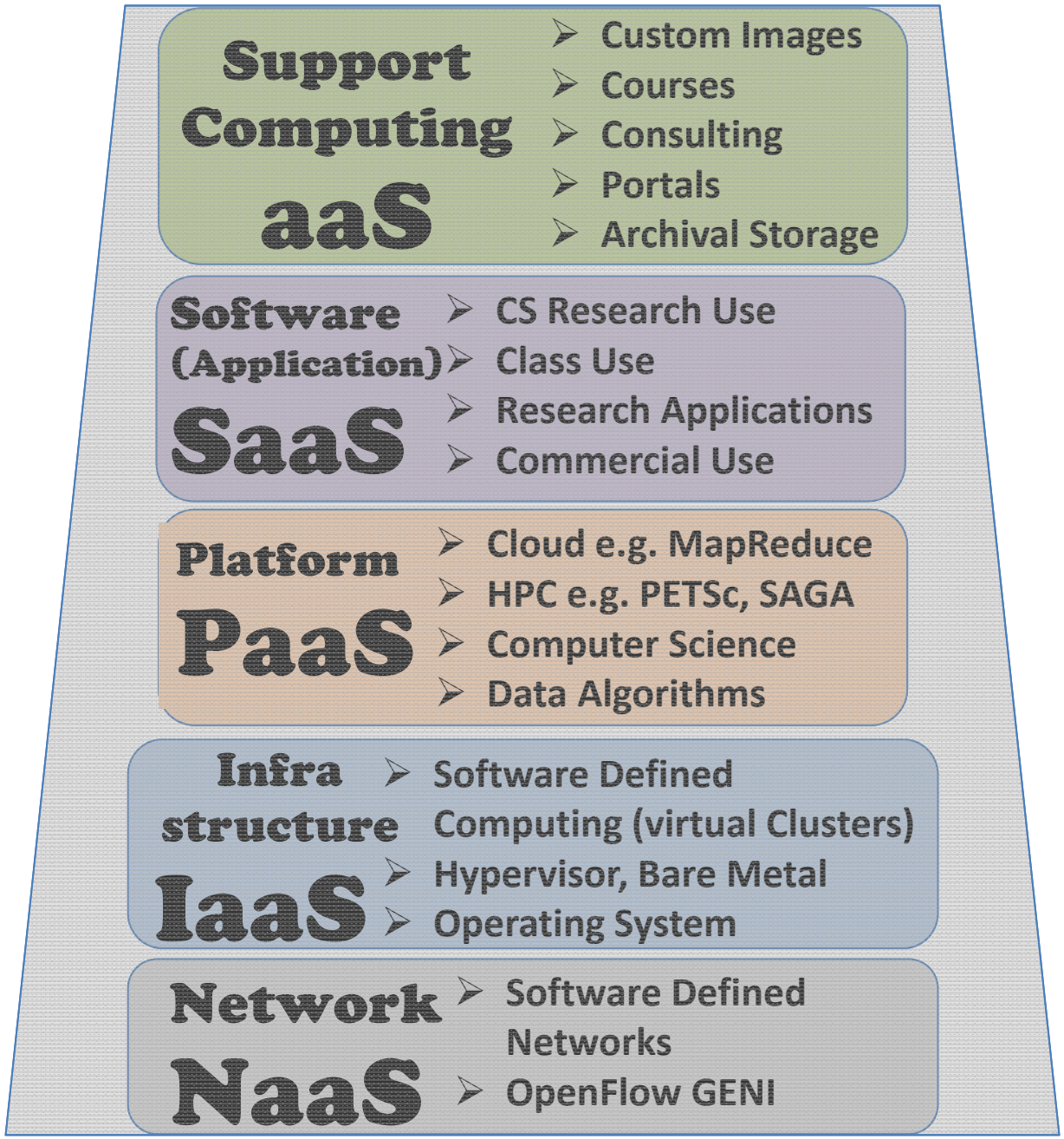


0.1 to 1000 millisecond latency

Everything is a message of some sort ……

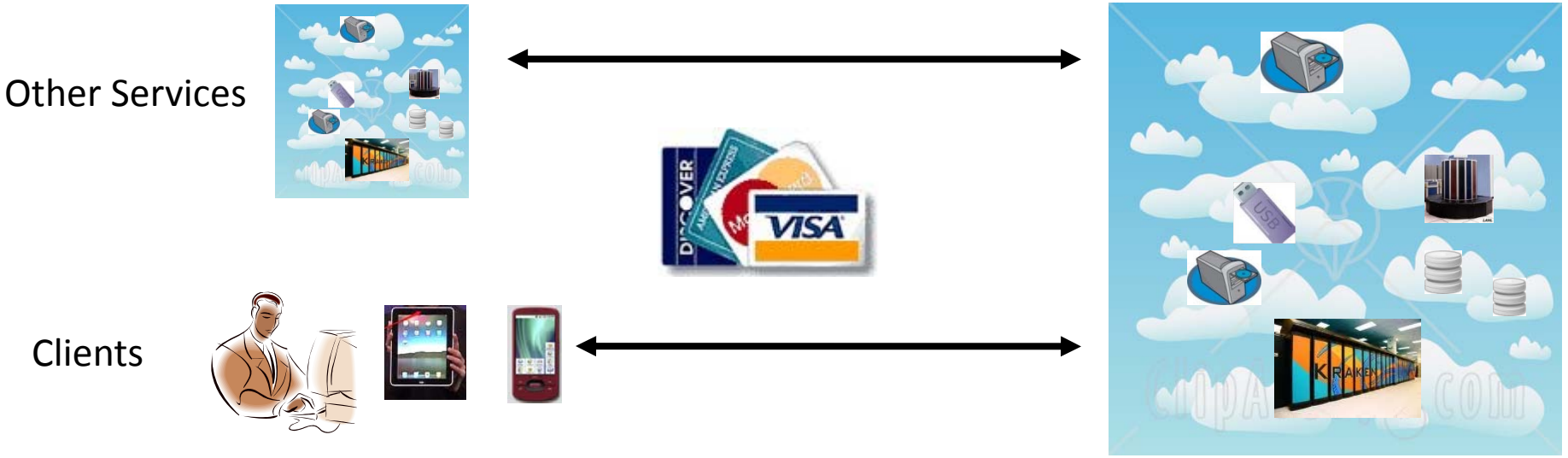
Different aaS (as aService)'s

- **IaaS:** Infrastructure is "renting" service for hardware
- **PaaS:** Convenient service interface to Systems capabilities
- **SaaS:** Convenient service interface to applications
- **NaaS:** Summarizes modern "Software Defined Networks"


Support Computing aaS
Custom Images
Courses
Consulting
Portals
Archival Storage
Software (Application) SaaS
CS Research Use
Class Use
Research Applications
Commercial Use
Platform PaaS
Cloud e.g. MapReduce
HPC e.g. PETSc, SAGA
Computer Science
Data Algorithms
Infra structure IaaS
Software Defined Computing (virtual Clusters)
Hypervisor, Bare Metal
Operating System
Network NaaS
Software Defined Networks
OpenFlow GENI

X as a Service

- SaaS: Software as a Service imply software capabilities (programs) have a service (messaging) interface
  - Applying systematically reduces system complexity to being linear in number of components
  - Access via messaging rather than by installing in /usr/bin
- IaaS: Infrastructure as a Service or HaaS: Hardware as a Service – get your computer time with a credit card and with a Web interface
- PaaS: Platform as a Service is IaaS plus core software capabilities on which you build SaaS
- Cyberinfrastructure is "Research as a Service"



http://www.slideshare.net/woorung/trend-and-future-of-cloud-computing

What is Cloud Computing?

Definitions of Cloud Computing

Wikipedia	n/a	Cloud computing is Internet- ("cloud-") based development and use of computer technology ("computing"). In concept, it is a paradigm shift whereby details are abstracted from the users who no longer need knowledge of, expertise in, or control over the technology infrastructure "in the cloud" that supports them. It typically involves the provision of dynamically scalable and often virtualized resources as a service over the Internet.
Gartner	Thomas Bittman	Cloud Computing: a style of computing where scalable and elastic IT-enabled capabilities are delivered as a service to external customers using Internet technologies.
AMR Research	Bruce Richardson, and esle	Cloud computing is the next-generation of software as a service, in which a complete software environment is licensed as a subscription from a software vendor and low-cost, secure, and dependable IT hardware infrastructure is 'rented' from a utility-computing provider on demand. … (omitted) …
THINKstrategies	Jeff Kaplan	A set of web-based tools and services which permit users to acquire computing resources and development capabilities to build or support applications, or perform specific IT functions on a pay-as-you-go basis.
Enterprise Strategy Group	Mark Bowker, Steve Duplessie	'Cloud computing' is nothing more than a service model where business workloads are deployed, transparently executed internally or somewhere on the Internet, and businesses only pay for what they consume. … (omitted) …
IDC	Frank Gens	Cloud Computing: an emerging IT development, deployment and delivery model, enabling real-time delivery of products, services and solutions over the Internet (i.e., enabling cloud services)
The 451 Group	Dan Kusnetzky, Rachel Chalmers, and else	'Cloud computing' describes a service model that combines a general organizing principle for IT delivery, infrastructure components, an architectural approach and an economic model - basically, a confluence of grid computing, virtualization, utility computing, hosting and software as a service (SaaS).
Forrester/Jupiter Research	James Staten	A standardized IT capability (services, software, or infrastructure) delivered via Internet technologies in a pay-per-use, self-service way.

More details are on http://jameskaskade.com/?p=594

What the $#@! is Cloud Computing

Squeezing the Definitions

- A computing environment to elastically provide virtualized resources as a service over the Internet in a pay-as-you-go manner
  - elastically: enable to avoid under-utilization(idle servers) and over-utilization(blue screen)
  - virtualized: enable to put whatever end user wants to use into the cloud, and access in anytime, anywhere, any devices
  - pay-as-you-go: enable a new ecosystem for end user, service provider, and vendors

http://www.slideshare.net/woorung/trend-and-future-of-cloud-computing

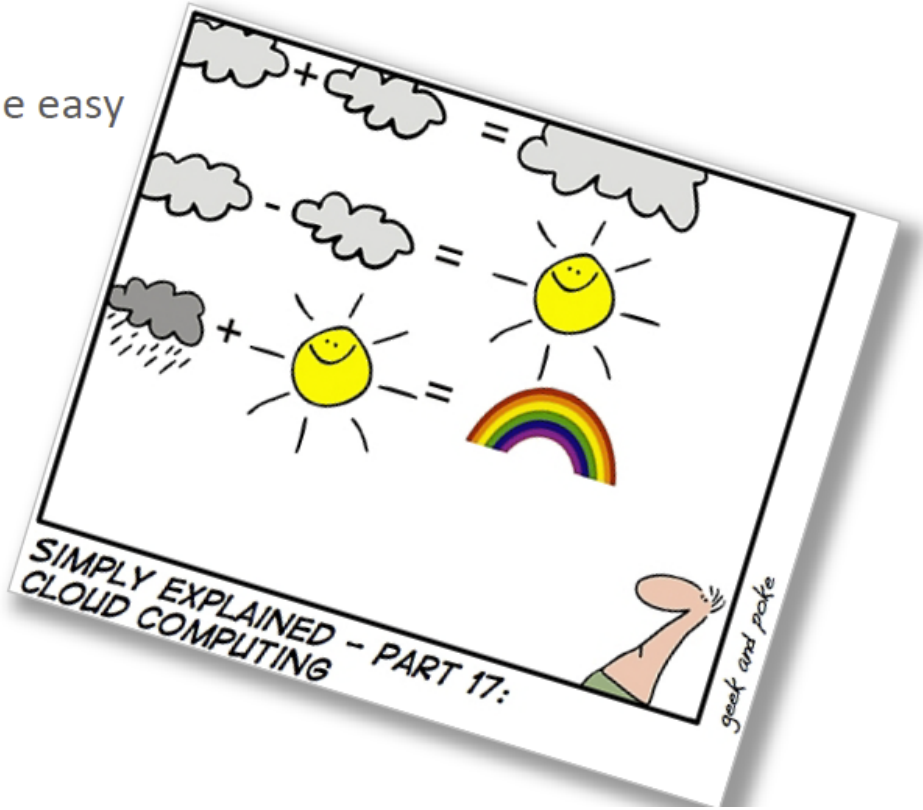
http://www.slideshare.net/JensNimis/cloud-computing-tutorial-jens-nimis

Some remarks on Cloud Definitions

- Anonymous:
  „[…] unfortunately the marketing guys got hold of the term before the technicians had known what Cloud Computing is […]“

- A lot of semi-serious definitions:
  - Cloud = Grid made right / Grid made easy
  - Grid: from Science for Science
    Cloud: from Business for Business

- Let‘s get serious (first…)



http://www.slideshare.net/JensNimis/cloud-computing-tutorial-jens-nimis

Some serious definitions

- **UCBerkeley RADLabs**: "Cloud computing has the following characteristics: (1) The illusion of infinite computing resources… (2) The elimination of an up-front commitment by Cloud users… (3). The ability to pay for use…as needed…"
  → business perspective

- **McKinsey**: "Clouds are hardware-based services offering compute, network and storage capacity where: Hardware management is highly abstracted from the buyer, Buyers incur infrastructure costs as variable OPEX, and Infrastructure capacity is highly elastic"
  → only one kind of Cloud

- **Wikipedia**: ".. a style of computing in which dynamically scalable and often virtualized resources are provided as a service over the Internet"
  → technical perspective

[JB]

http://www.slideshare.net/JensNimis/cloud-computing-tutorial-jens-nimis

Our definition

FZI

> "Building on compute and storage virtualization, ***cloud computing*** provides scalable, network-centric, abstracted IT infrastructure, platforms, and applications as on-demand services that are billed by consumption."

Common ground:

- Web Service and Web Portal access
- Scalability
- Pay per use
- Virtualisation/abstraction
- XaaS

→ Technical enablers:

- WS-Technology: SOAP, REST,…
- Virtualization: VMWare, XEN, Virtual Box,…

Gartner’s Technology Landscape

Gartner Top 10 Strategic Technologies

Gartner Top 10 Strategic Technologies for Last 6 years

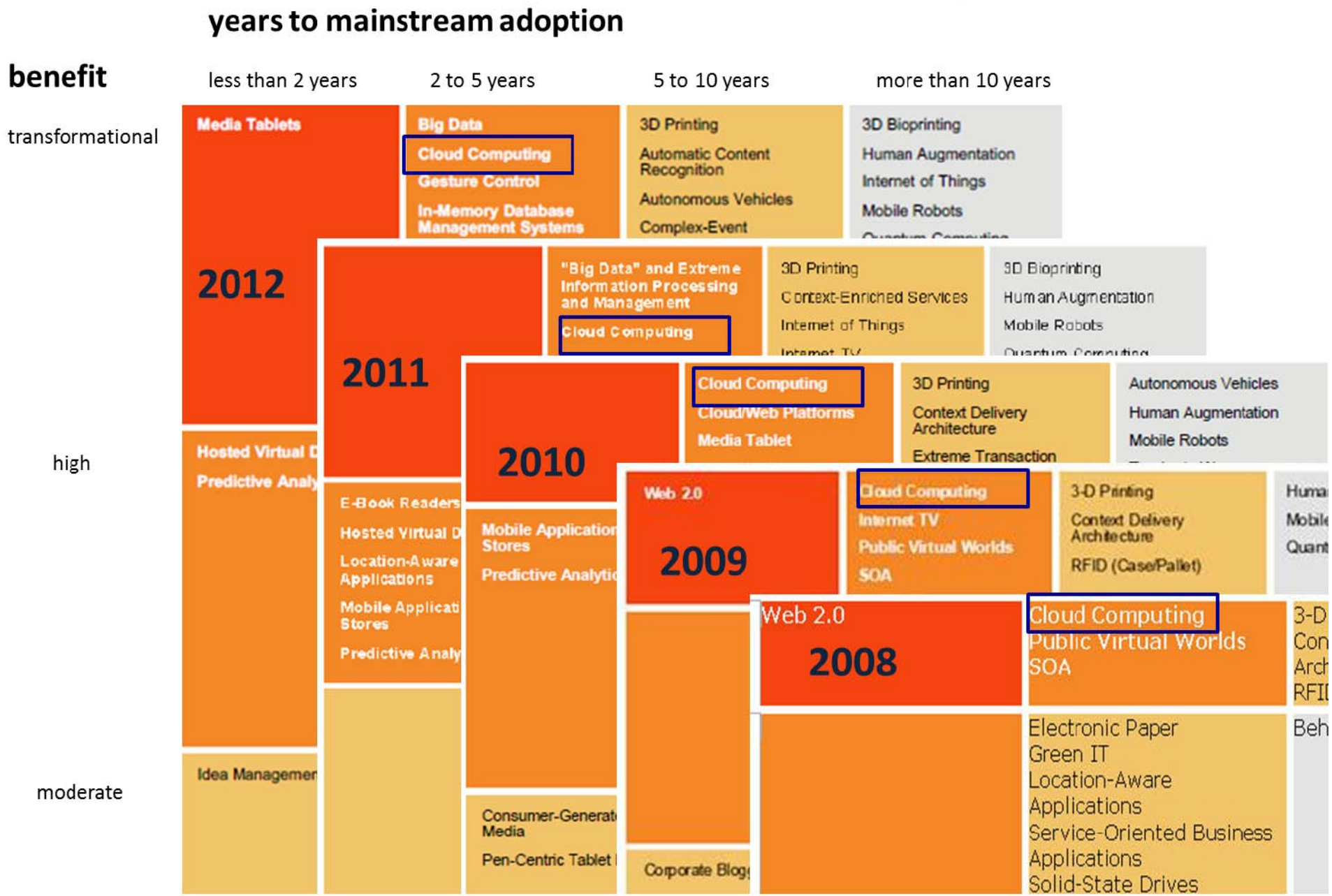
	For 2004	For 2005	For 2006	For 2007	For 2008	For 2009
1	Grid Computing	Grid	AJAX	Web 2.0 – AJAX Rich Clients	Green IT	Virtualization
2	Instant Messaging	Instant Messaging	Collective Intelligence	Business Process Management Suites	Unified Communications	Cloud Computing
3	Internal Web Services	IP Telephony	Enterprise Information Management	Communities and Collective Intelligence	Business Process Modelling	Servers — Beyond Blades
4	IP Telephony	Location-aware Services	Grid Computing	Enterprise Information Management	Metadata Management	Web-Oriented Architectures
5	Network Security Technologies	Mesh networks	Information Access	Information Access	Virtualization 2.0	EnterpriseMashups.
6	Policy-Based Management	OLED/LEP	Mashup Composite Model	Web 2.0 – Mashup Composite Model	Mashup & Composite Apps	Specialized Systems
7	Real-Time Data Warehouse	Real-Time Infrastructure	Open Source	Open Source	Web Platform & WOA	Social Software and Social Networking
8	RFID Tags	RFID Tags	Pervasive Computing	Service Registries and Repositories	Computing Fabric	Unified Communications
9	Utility Computing	Software as Services	Service-Oriented Architecture	Ubiquitous Computing	Real World Web	Business Intelligence
10	Wi-Fi Security	Taxonomies	Virtualization	Virtualization	Social Software	Green IT

Stolen from http://www.flickr.com/photos/mobian/3426349990/

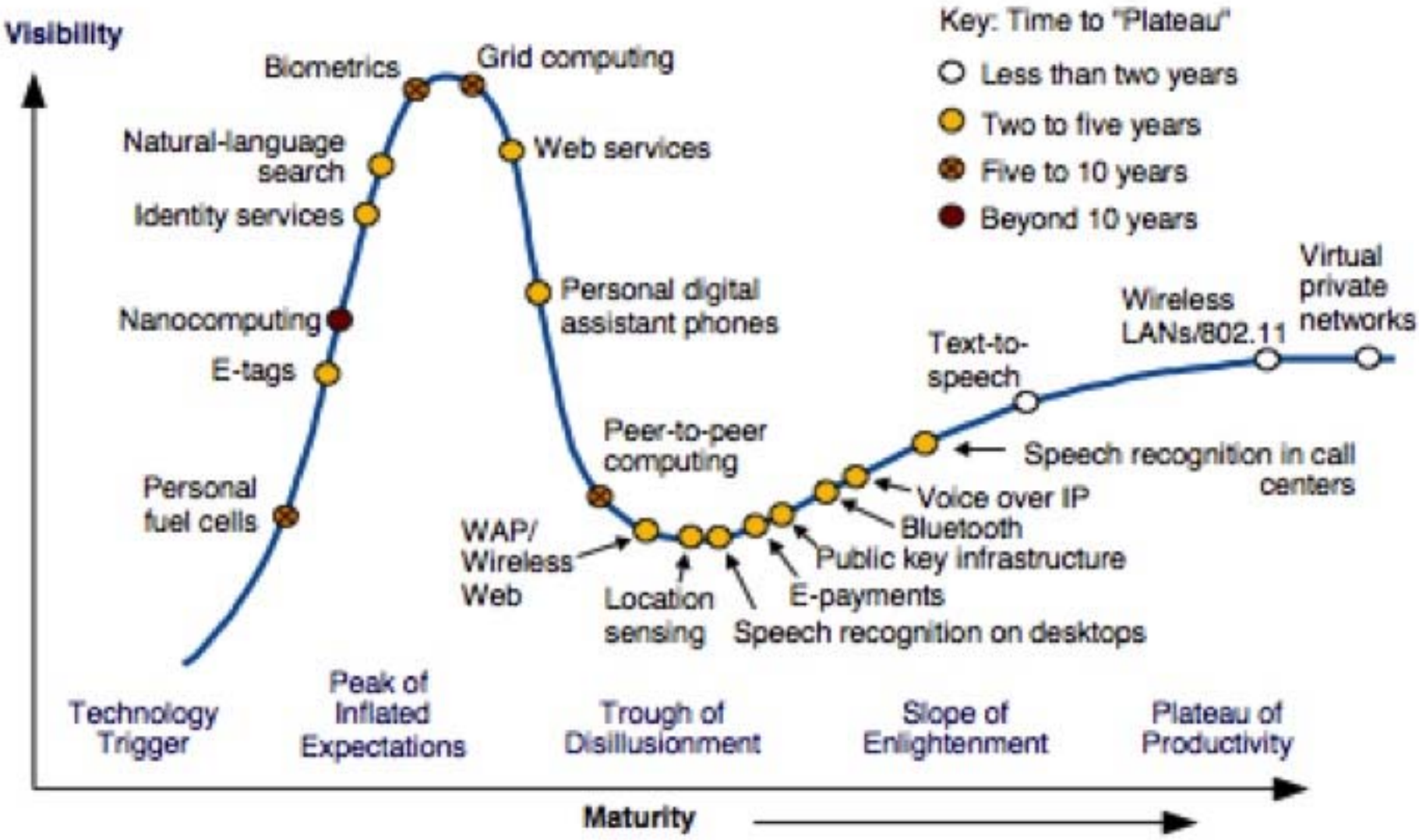
http://www.slideshare.net/woorung/trend-and-future-of-cloud-computing

coord

Gartner Priority Matrix

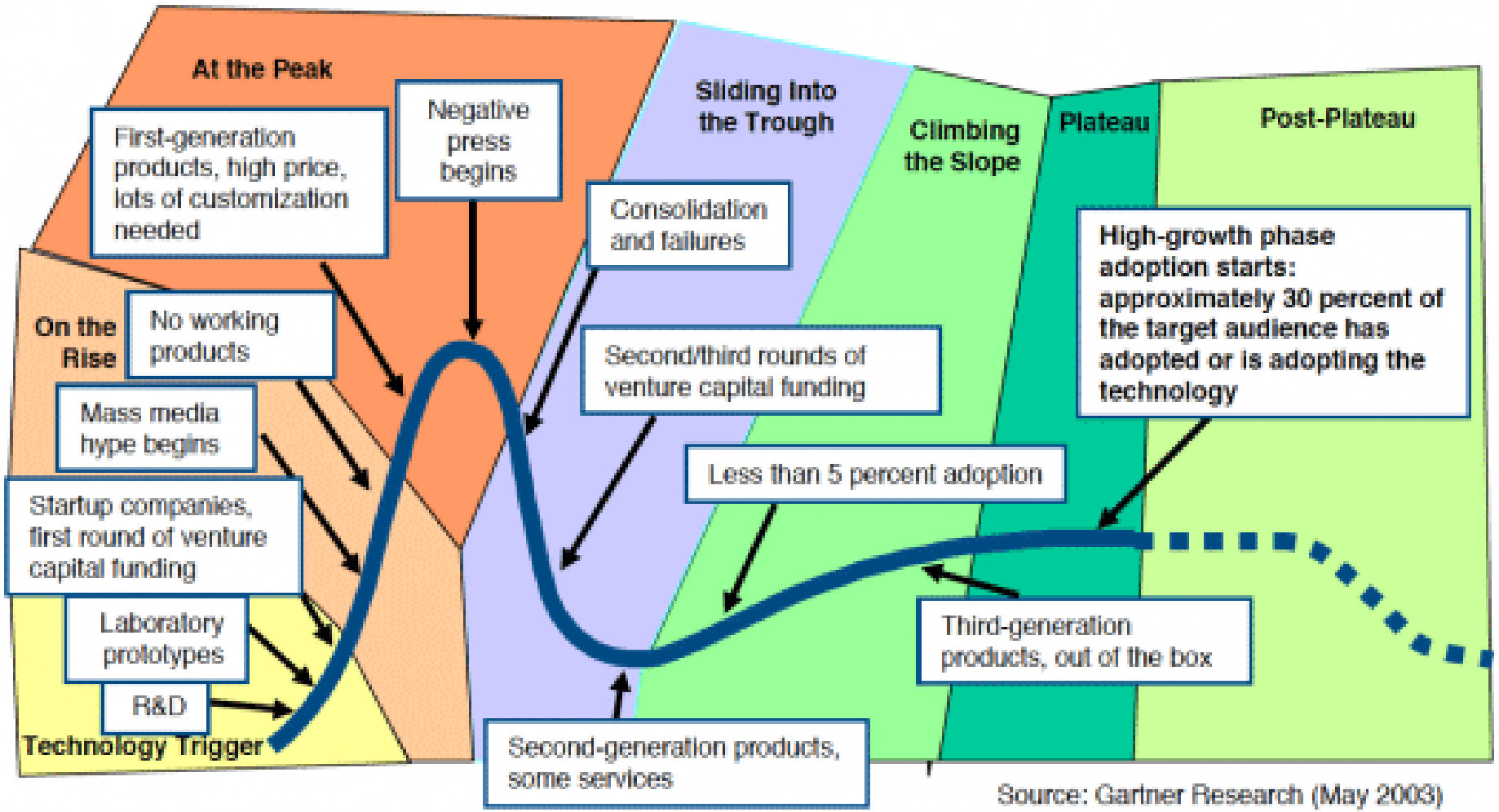


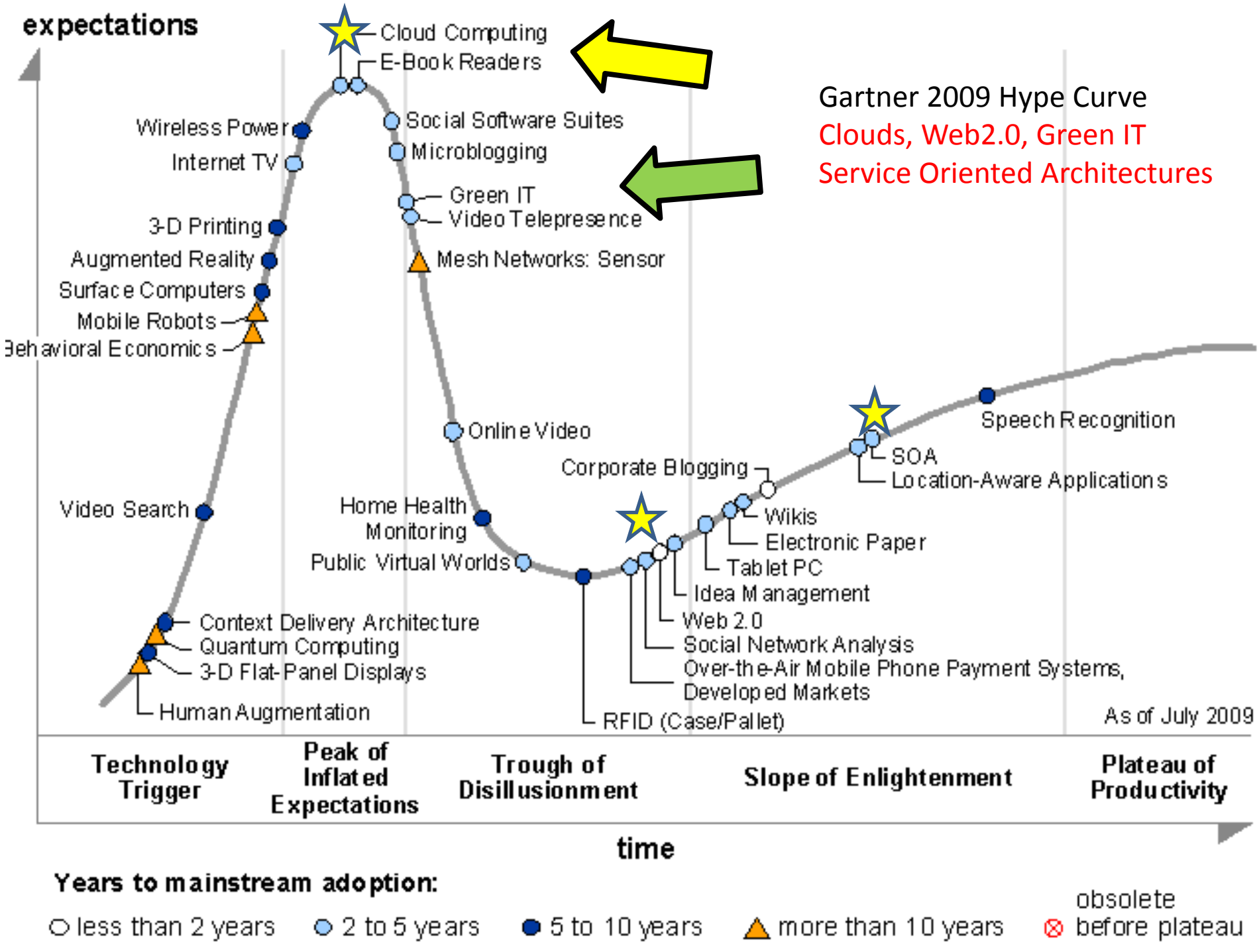
Gartner Emerging Technologies Hype Cycle 2002



Hype Cycle

Describes Stock Prices, Popularity of artists etc.?

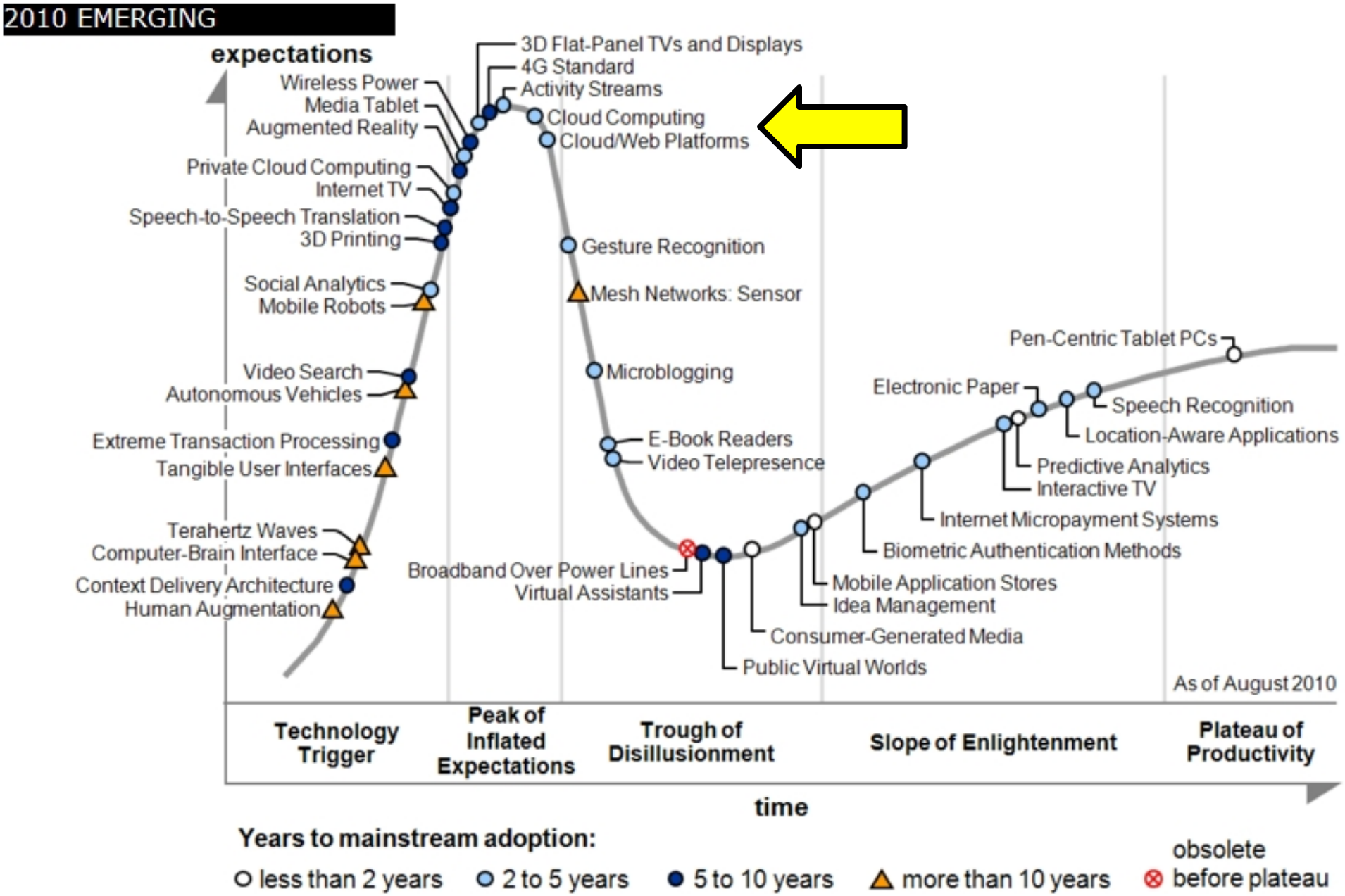


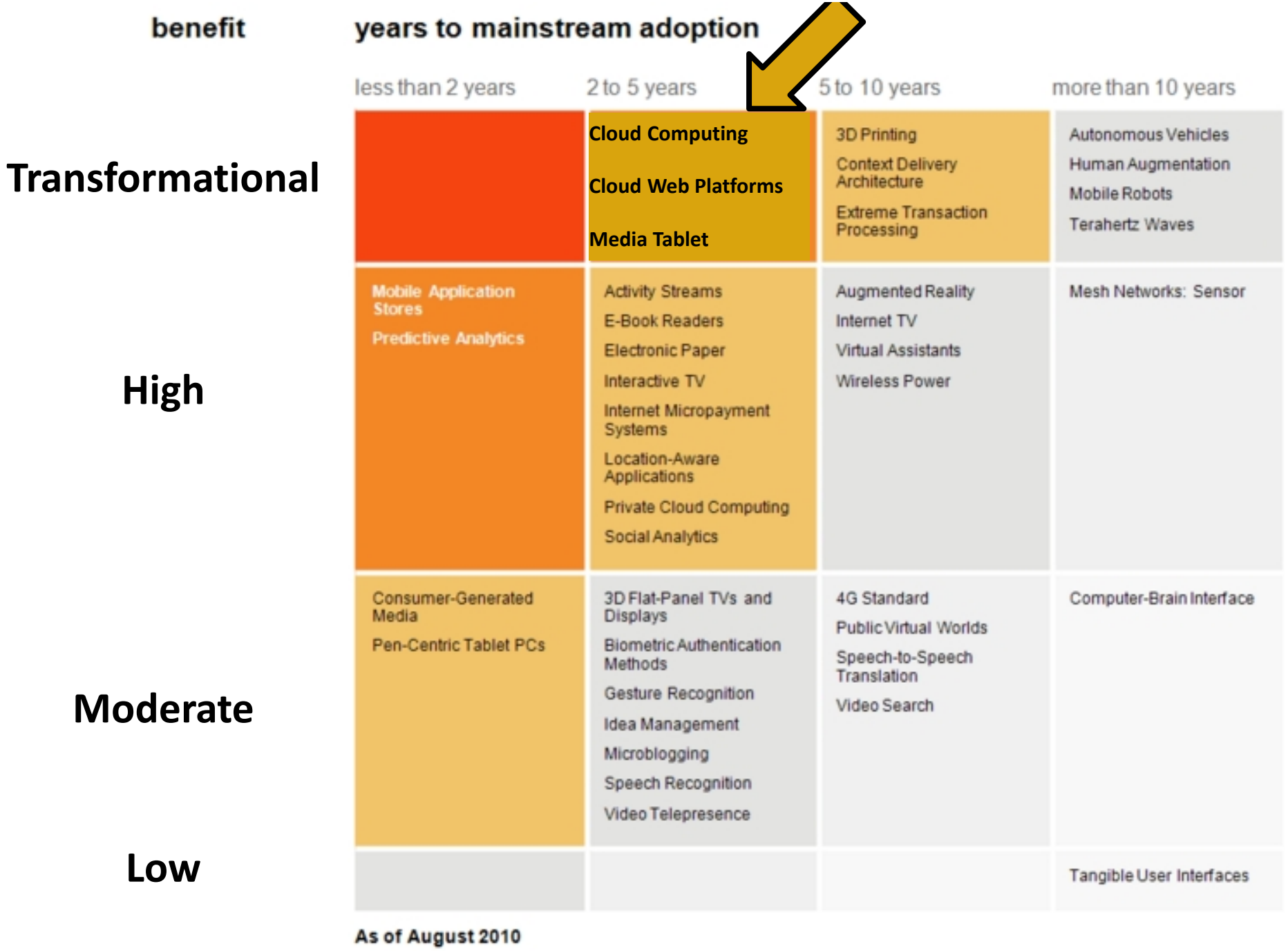


Gartner 2009 Hype Curve

Clouds, Web2.0, Green IT

Service Oriented Architectures


2010 EMERGING
expectations
3D Flat-Panel TVs and Displays
4G Standard
Activity Streams
Cloud Computing
Cloud/Web Platforms
Wireless Power
Media Tablet
Augmented Reality
Private Cloud Computing
Internet TV
Speech-to-Speech Translation
3D Printing
Social Analytics
Mobile Robots
Video Search
Autonomous Vehicles
Extreme Transaction Processing
Tangible User Interfaces
Terahertz Waves
Computer-Brain Interface
Context Delivery Architecture
Human Augmentation
Gesture Recognition
Mesh Networks: Sensor
Microblogging
E-Book Readers
Video Telepresence
Broadband Over Power Lines
Virtual Assistants
Public Virtual Worlds
Consumer-Generated Media
Mobile Application Stores
Idea Management
Biometric Authentication Methods
Internet Micropayment Systems
Predictive Analytics
Interactive TV
Electronic Paper
Pen-Centric Tablet PCs
Speech Recognition
Location-Aware Applications
As of August 2010
Technology Trigger
Peak of Inflated Expectations
Trough of Disillusionment
Slope of Enlightenment
Plateau of Productivity
time
Years to mainstream adoption:
less than 2 years
2 to 5 years
5 to 10 years
more than 10 years
obsolete before plateau


benefit
years to mainstream adoption
less than 2 years
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Transformational
Cloud Computing
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Context Delivery Architecture
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High
Mobile Application Stores
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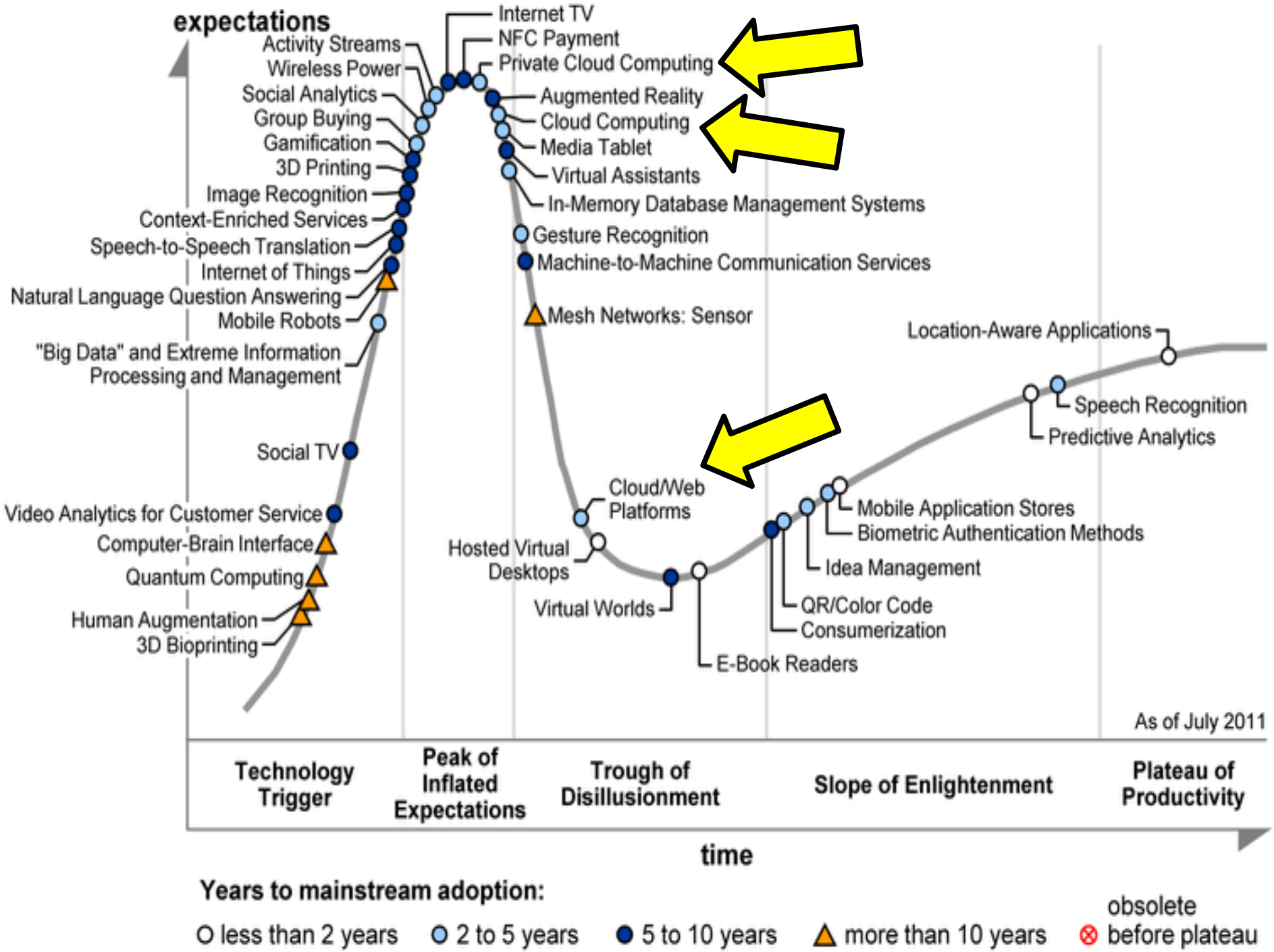
Tangible User Interfaces
As of August 2010


expectations
Internet TV
NFC Payment
Private Cloud Computing
Activity Streams
Wireless Power
Social Analytics
Group Buying
Gamification
3D Printing
Image Recognition
Context-Enriched Services
Speech-to-Speech Translation
Internet of Things
Natural Language Question Answering
Mobile Robots
"Big Data" and Extreme Information Processing and Management
Augmented Reality
Cloud Computing
Media Tablet
Virtual Assistants
In-Memory Database Management Systems
Gesture Recognition
Machine-to-Machine Communication Services
Mesh Networks: Sensor
Location-Aware Applications
Speech Recognition
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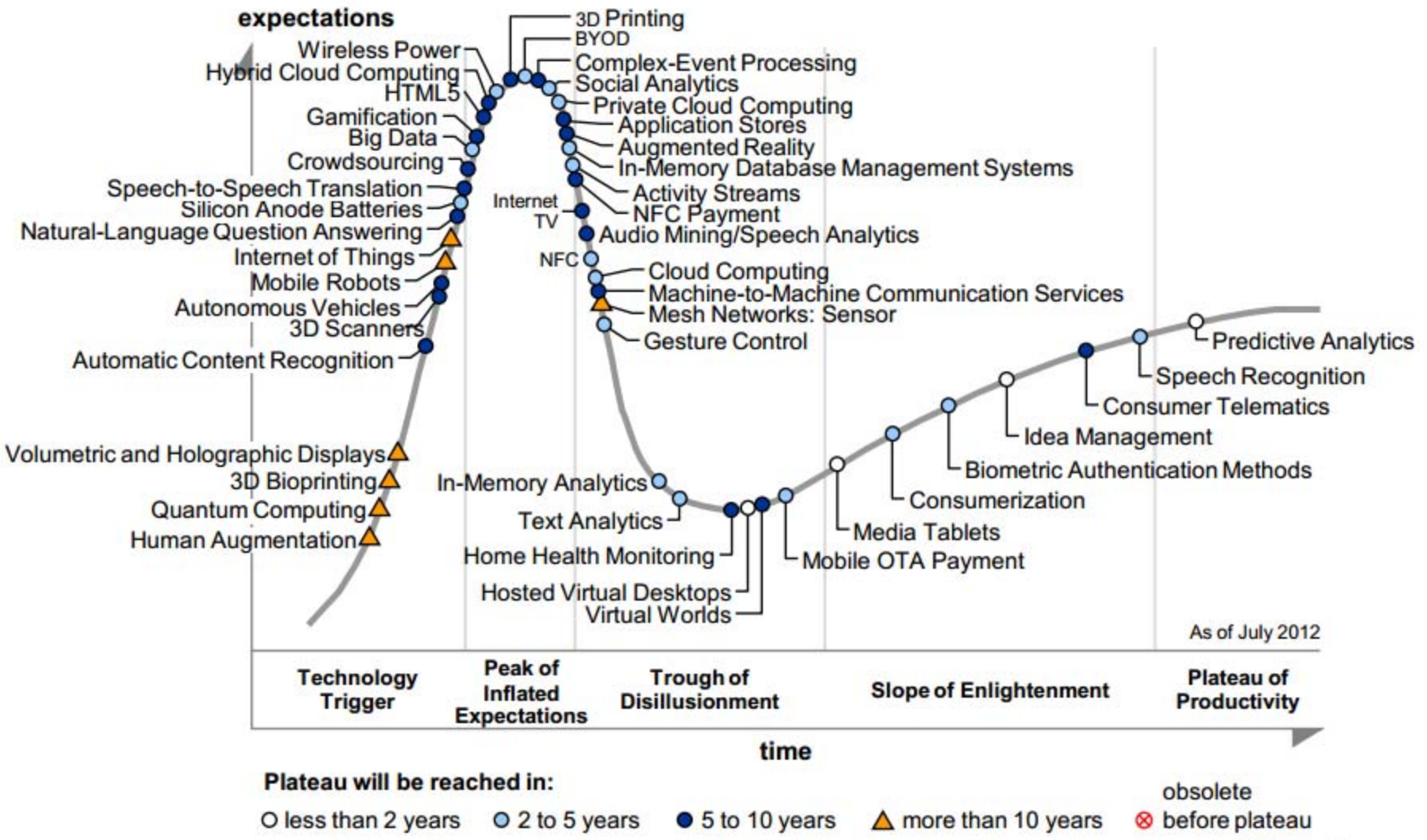
Emerging Technologies Hype Cycle 2012



Gartner

Summary of the Gartner Hype Cycle for "Emerging Technologies" for 2012

- *http://setandbma.wordpress.com/2012/08/10/hype-cycle-2012-emerging-technologies/*
- What is stated explicitly, what can be inferred.
- This Hype Cycle is suppose provide insight into emerging technologies that have broad, cross-industry relevance, and are transformational and high impact in potential.
- ***Most crowded hype cycle on emerging technologies in last 10 years***
- 48 technologies are listed in this year's hype cycle which is the highest in last ten years. Last year they had 42 – year 2008 was the lowest (27) – year 2005 was the previous highest (44).
- What does this imply?
- May be Gartner is right when it says:
- ***We are at an interesting moment — a time when the scenarios we've been talking about for a long time are almost becoming reality.***

Which macro trends are stated explicitly in the report?

- http://setandbma.wordpress.com/2012/08/10/hype-cycle-2012-emerging-technologies/
- Any Channel, Any Device, Anywhere — Bring Your Own Everything
- Smarter Things – things are smart and connected to the Internet
- Big Data and Global-Scale Computing at Small Prices
- The Human Way to Interact with Technology – speech, gesture etc.
- What Payment Could Really Become – NFC (Near Field Communication), Mobile OTA (over The Air) etc.
- The Voice of the Customer Is on File – making sense of behavior data already available
- 3D Print It at Home
- **2 Implicit trends**
- **Consumerization of IT** describes the trend where technologies are adopted by consumer ahead of enterprise & government & science.
- **Hyper-connectivity** is about connecting everything us-to-internet; things-to-internet; peer-to-peer; consumer-to-enterprise; enterprise-to-enterprise… and so on

14 of 48 are technologies for reaching out or interacting with consumers

- Application Stores
- Augmented Reality
- BYOD (Bring your own device)
- Consumer Telematics
- Consumerization (This is not a technology – it is a trend)
- Gamification
- Home Health Monitoring
- HTML5
- Internet TV
- Media Tablets
- Mobile OTA (over The Air) Payment
- NFC (Near Field Communication)
- NFC Payment
- Virtual Worlds
- *From http://setandbma.wordpress.com/2012/08/10/hype-cycle-2012-emerging-technologies/*

8 of 48 are about analyzing, understanding and taking advantage of consumer behavior

- Activity Streams
- Big Data
- Complex-Event Processing
- Crowdsourcing
- In-Memory Analytics
- Predictive Analytics
- Social Analytics
- Text Analytics
- *From http://setandbma.wordpress.com/2012/08/10/hype-cycle-2012-emerging-technologies/*

3 of 48 are about connecting things

- Internet of Things
- Machine-to-Machine Communication Services
- Mesh Networks: Sensor
- *From http://setandbma.wordpress.com/2012/08/10/hype-cycle-2012-emerging-technologies/*

10 of 48 are technologies for AI and Robotics nearing the Tipping Point

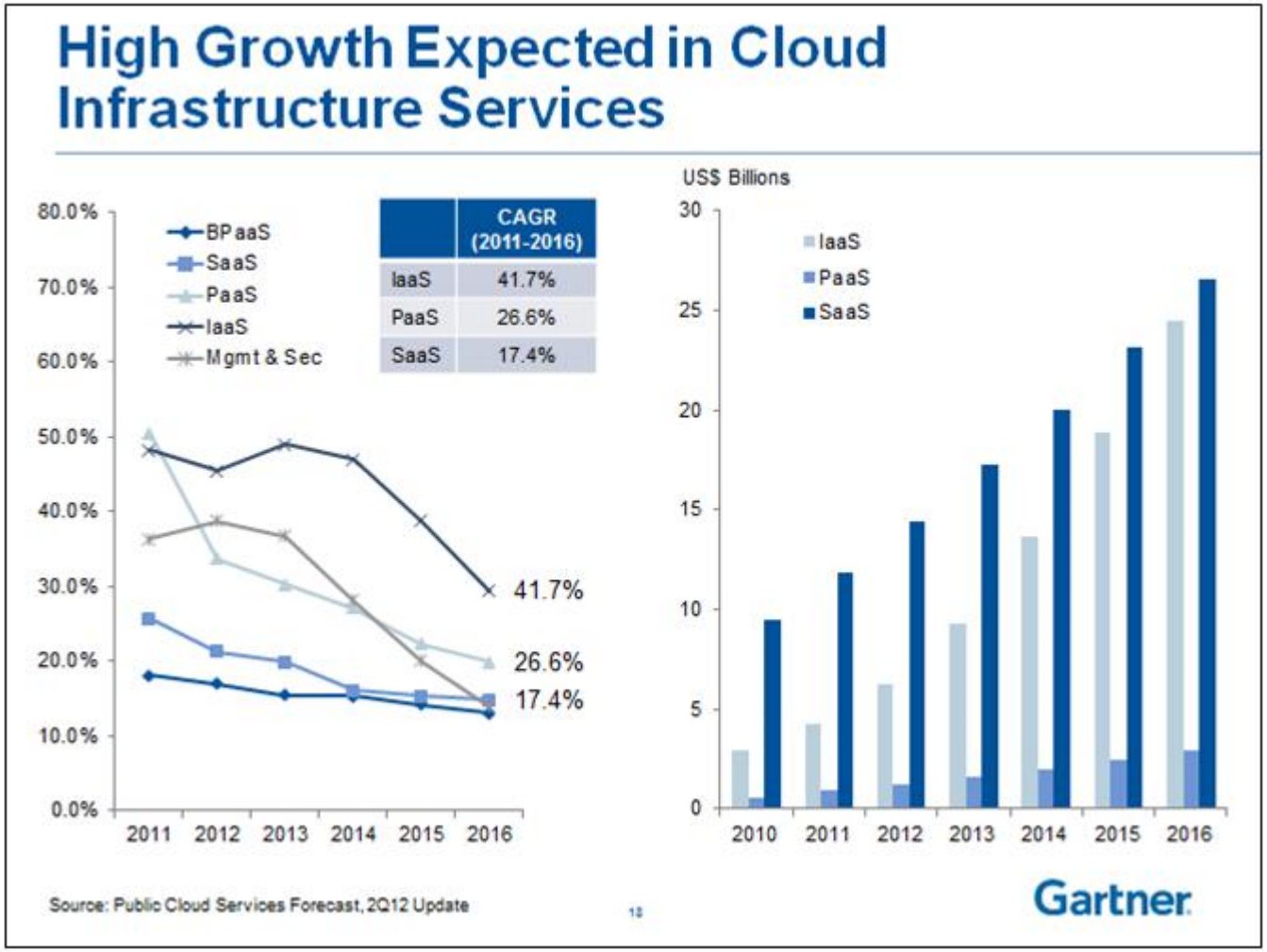
- Audio Mining/Speech Analytics
- Automatic Content Recognition
- Autonomous Vehicles
- Biometric Authentication Methods
- Gesture Control
- Human Augmentation
- Mobile Robots
- Natural-Language Question Answering
- Speech Recognition
- Speech-to-Speech Translation
- *From http://setandbma.wordpress.com/2012/08/10/hype-cycle-2012-emerging-technologies/*

6 of 48 are technologies for improving efficiency or for reducing cost

- Cloud Computing
- Hosted Virtual Desktops
- Hybrid Cloud Computing
- Idea Management
- In-Memory Database Management Systems
- Private Cloud Computing
- *From http://setandbma.wordpress.com/2012/08/10/hype-cycle-2012-emerging-technologies/*

7 of 48 are miscellaneous technologies most of them very futuristic in nature

- 3D Bio-printing
- 3D Printing
- 3D Scanners
- Quantum Computing
- Silicon Anode Batteries
- Volumetric and Holographic Displays
- Wireless Power
- *From* *http://setandbma.wordpress.com/2012/08/10/hype-cycle-2012-emerging-technologies/*



IaaS Hardware e.g. Server
PaaS Systems Services e.g. MapReduce, Database
SaaS Applications e.g. Recommender System, Clustering
BPaaS Particular Application Set

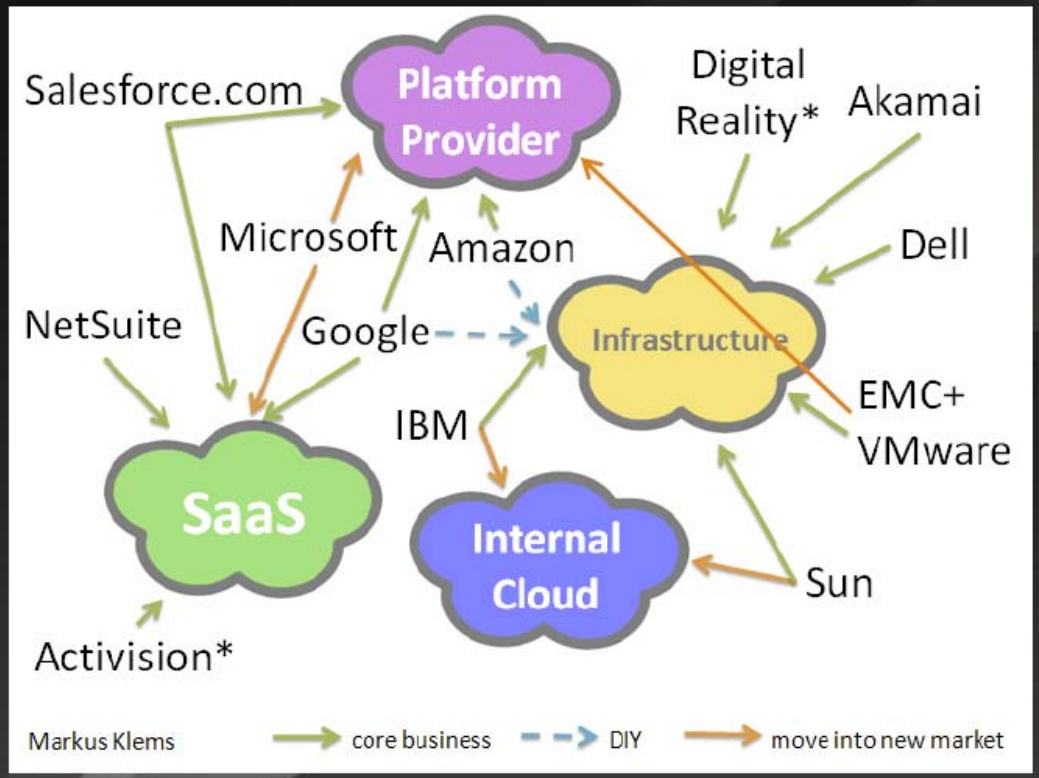
BPM = Business Process management

http://www.slideshare.net/woorung/trend-and-future-of-cloud-computing

Cloud Wars

Merrill Lynch recently issues a research note

- "The Cloud Wars: $100+ billion at stake" (07 May 2008).
  - The analysts write that by 2011 the volume of cloud computing market opportunity would amount to $160bn, including $95bn in business and productivity apps (email, office, CRM, etc.) and $65bn in online advertising.



Stolen from http://markusklems.wordpress.com/2008/07/05/merill-in-the-cloud/

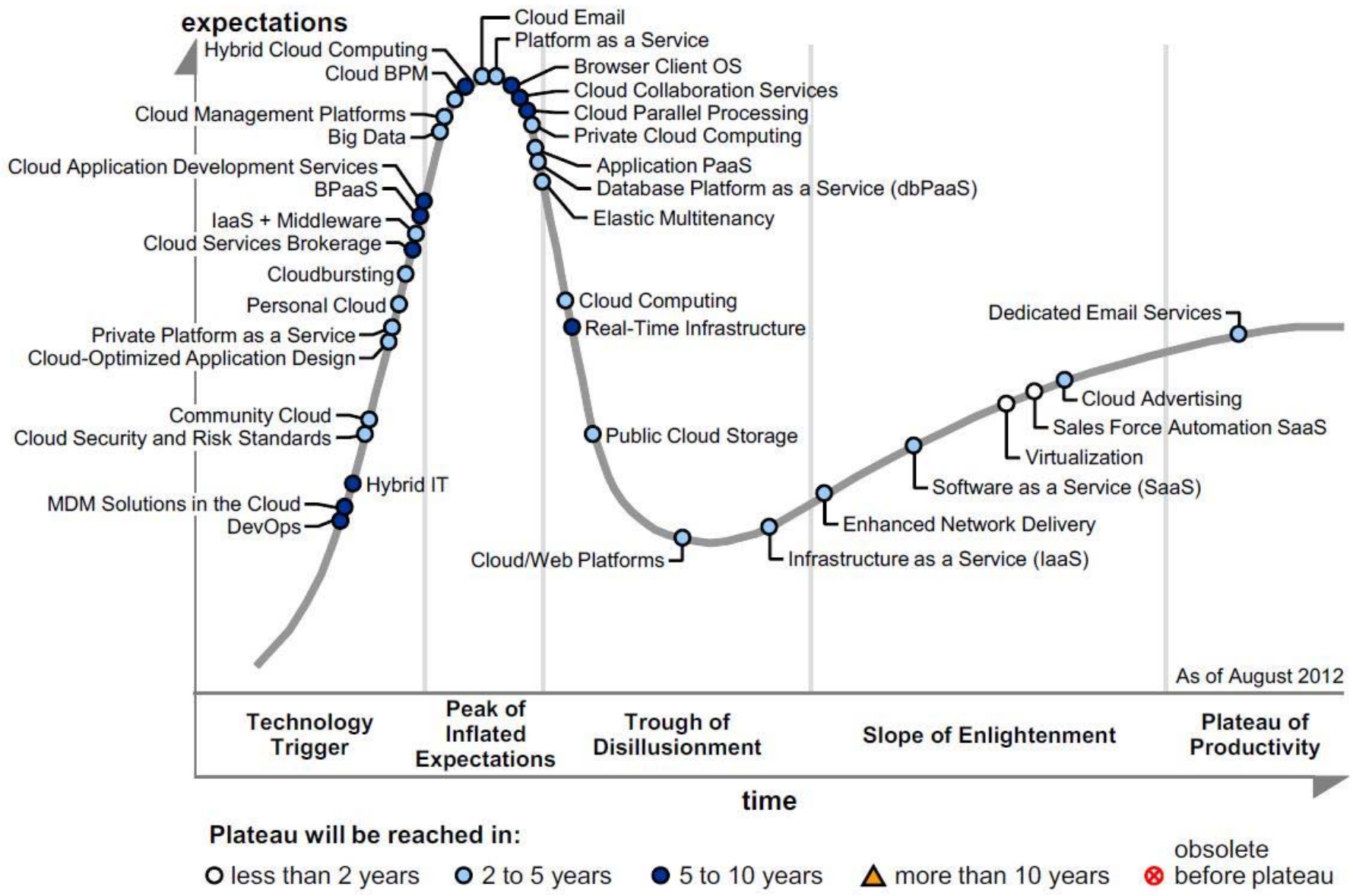
Figure 2. Priority Matrix for Cloud Computing, 2012

benefit	years to mainstream adoption			
	less than 2 years	2 to 5 years	5 to 10 years	more than 10 years
transformational	**Virtualization**	**Big Data** **Cloud Advertising** **Cloud Computing** **Community Cloud** **Platform as a Service**	DevOps Hybrid Cloud Computing Real-Time Infrastructure	
high		Application PaaS Cloud BPM Cloud Management Platforms Cloud Security and Risk Standards Cloud/Web Platforms Cloudbursting Cloud-Optimized Application Design Elastic Multitenancy Enhanced Network Delivery Infrastructure as a Service (IaaS) Personal Cloud Private Cloud Computing	Cloud Application Development Services Cloud Parallel Processing Cloud Services Brokerage Hybrid IT	
moderate	Sales Force Automation SaaS	Cloud Email Database Platform as a Service (dbPaaS) IaaS + Middleware Private Platform as a Service Public Cloud Storage Software as a Service (SaaS)	BPaaS Cloud Collaboration Services MDM Solutions in the Cloud	
low		Dedicated Email Services	Browser Client OS	

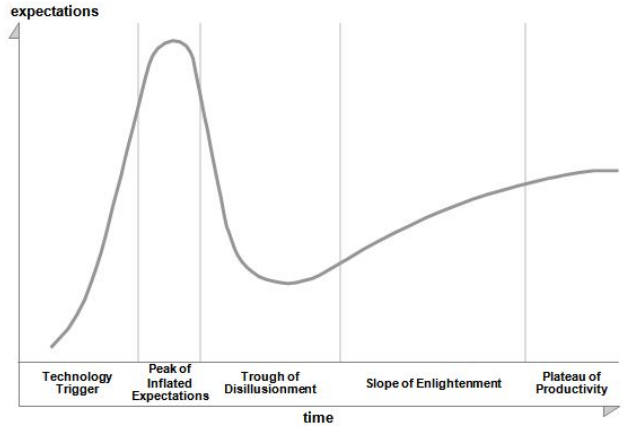
As of August 2012

Source: Gartner (August 2012)

Figure 1. Hype Cycle for Cloud Computing, 2012



Source: Gartner (August 2012)



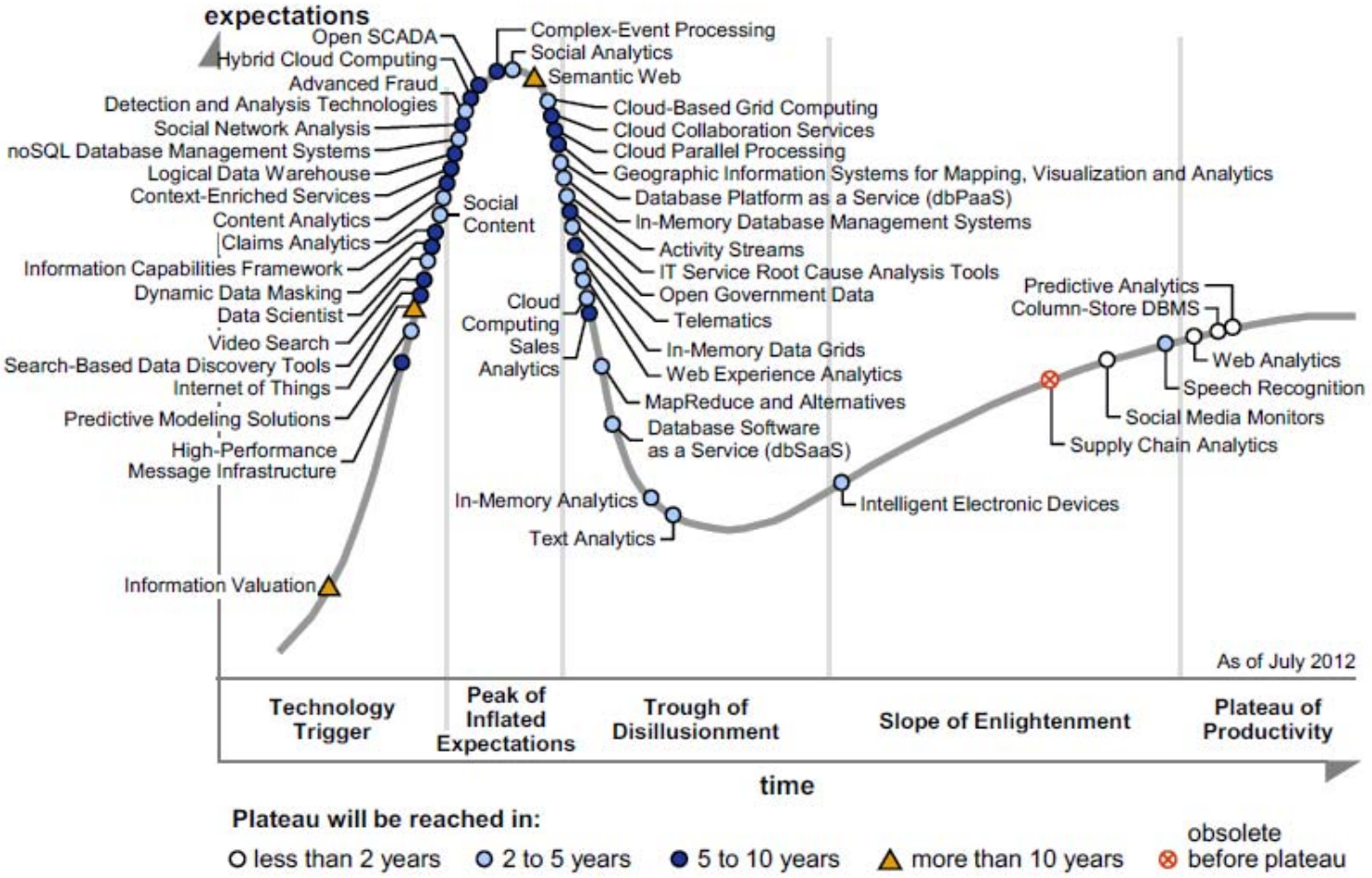
Gartner Hype Cycle: Where is Big Data Now?

The hype over "Big Data" is about to plunge into widespread disillusionment, according to a Gartner analyst.

- Big Data is plunging into a "trough of disillusionment" that will dissuade many companies from pursuing analytics technology, according to a Gartner analyst.
- Gartner regularly updates what it terms the Hype Cycle, in which technologies progress from rising interest, to overexposure, to the Dante-style "trough of disillusionment," and finally to eventual rehabilitation as productive and well-integrated technologies. Everything from cloud computing to media tablets goes through these stages; and now, according to Svetlana Sicular, Big Data is about to take the plunge into widespread disappointment and discontent.
- Who's responsible for shoving Big Data over that cliff? Users have apparently realized that dealing with massive datasets and complex analytical tools is hard. "My most advanced with Hadoop clients are also getting disillusioned," Sicular wrote in a Jan. 22 blog posting on the Gartner Website. "Their disappointment applies to more advanced cases of sentiment analysis, which go beyond traditional vendor offerings."

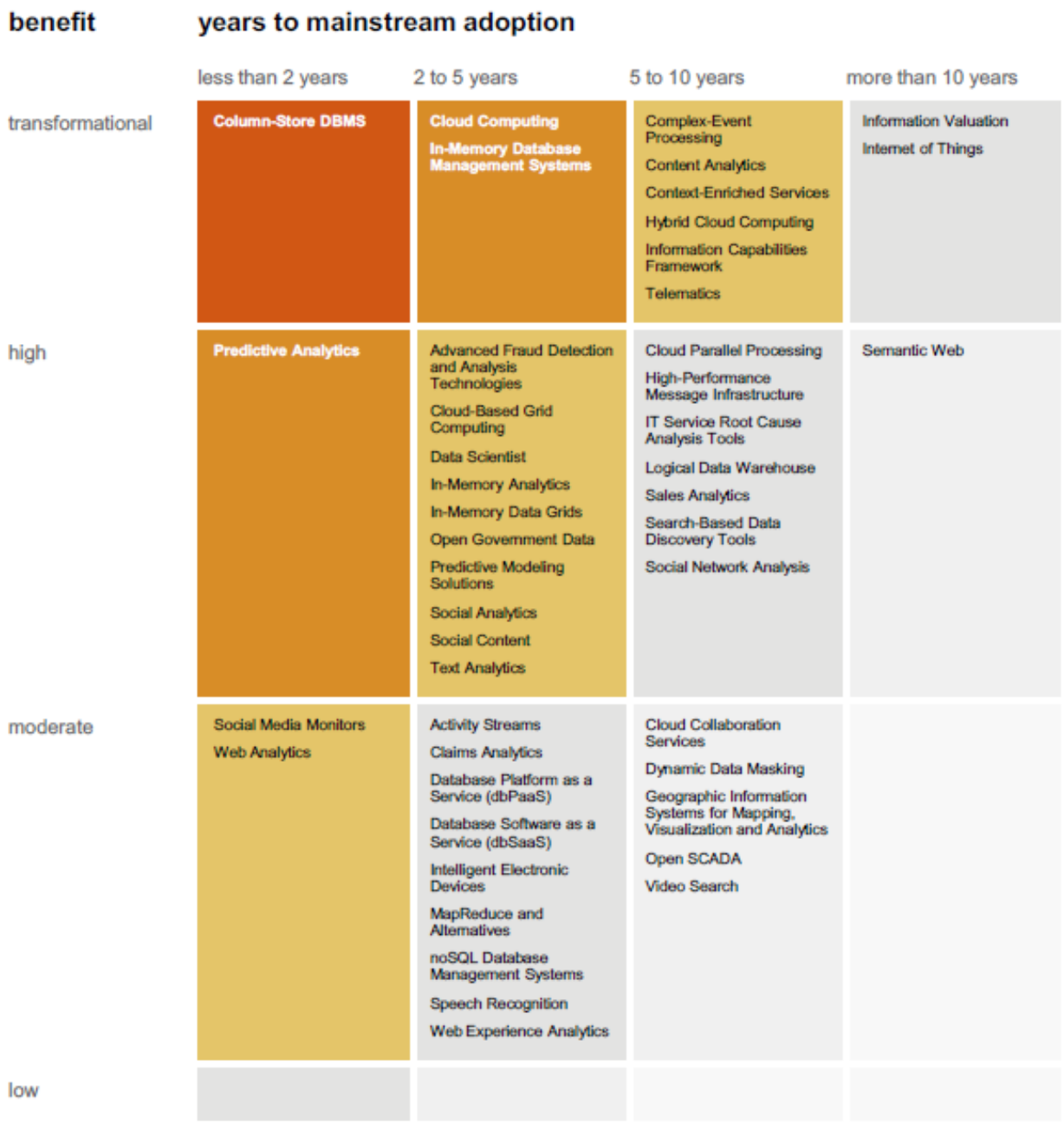
http://slashdot.org/topic/bi/big-data-hype-is-imploding-gartner-analyst/

Figure 1. Hype Cycle for Big Data, 2012

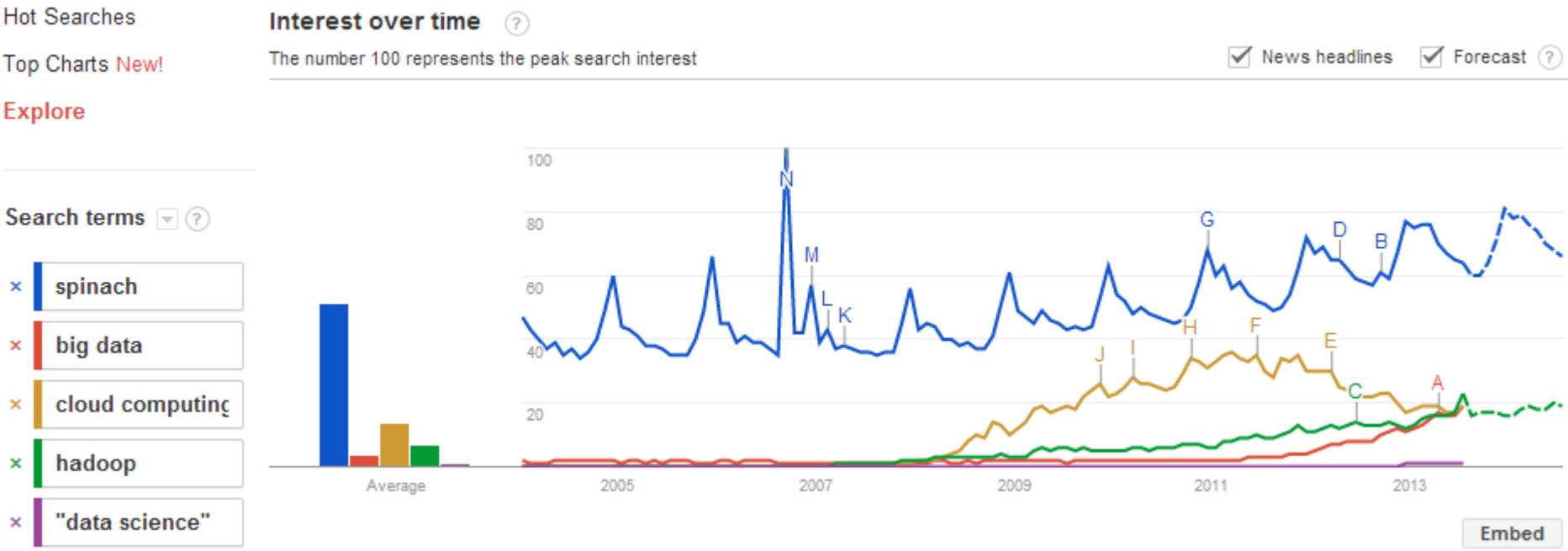


Source: Gartner (July 2012)

Figure 2. Priority Matrix for Big Data, 2012



Google Trends

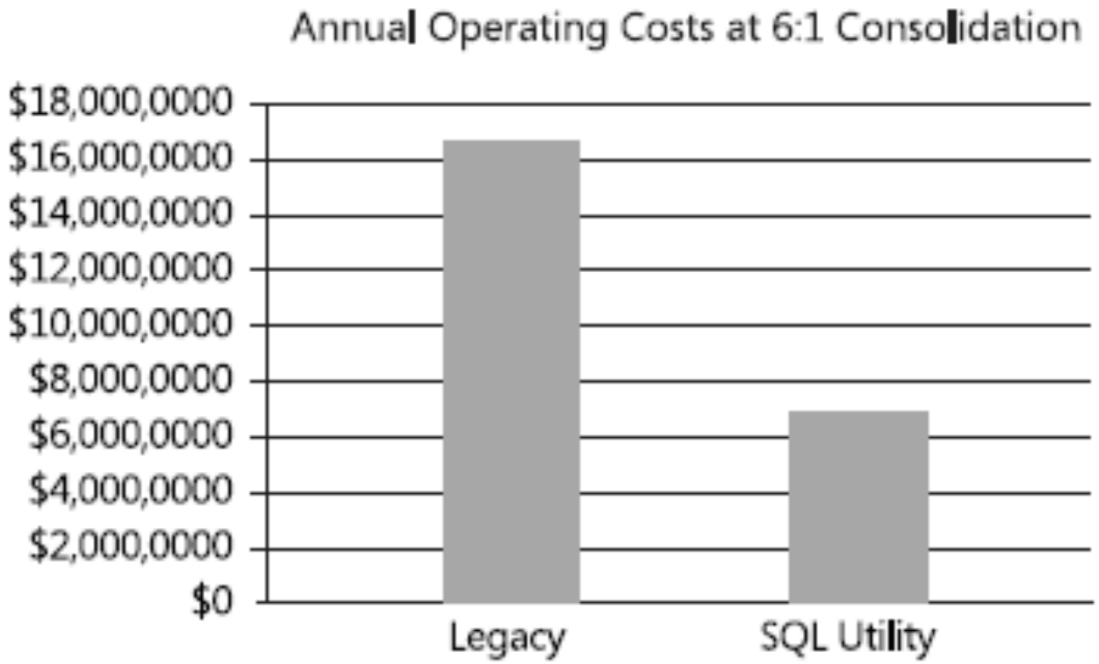


- Spinach is more important than our topics …….

Simple Examples

Microsoft Server Consolidation

- http://research.microsoft.com/pubs/78813/AJ18_EN.pdf
- Typical data center CPU has 9.75% utilization
- Take 5000 SQL servers and rehost on virtual machines with 6:1 consolidation



60% saving

The Google gmail example

- http://www.google.com/green/pdfs/google-green-computing.pdf
- Clouds win by efficient resource use and efficient data centers

Business Type	Number of users	# servers	IT Power per user	PUE (Power Usage effectiveness)	Total Power per user	Annual Energy per user
Small	50	2	8W	2.5	20W	175 kWh
Medium	500	2	1.8W	1.8	3.2W	28.4 kWh
Large	10000	12	0.54W	1.6	0.9W	7.6 kWh
Gmail (Cloud)	∞	∞	< 0.22W	1.16	< 0.25W	< 2.2 kWh