

Cloud Computing & HP Labs

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Today's Presentation

- HP and HP Labs
- Cloud Computing
 - Evolution to the Cloud
 - What is Cloud Computing?
 - Benefits
 - Barriers
- HP Labs Research Example
 - 'Cells as a Service' – A Virtual Infrastructure Service



HP today

- Fortune 14 - US
Fortune 41 - Global
- 172,000 employees
- Revenue for the year ended July 31, 2008: \$113.1 Bn



Leadership across the board

Worldwide data for calendar CQ1 2008



	SHARE	POSITION
Blade Servers ¹	46.9%	#1
x86 based Servers ¹	34.4%	#1
Unix + Linux + Windows Servers ¹	33.1%	#1
Branded Tape Drives ^{1,5}	25.0%	#2
Disk Storage Systems ¹	19.4%	#2
SAN Systems ^{1,6}	14.1%	#3
Automated Software Quality	45.9%	#1
Distributed system management software	17.1%	#1
IT project and portfolio management	10.8%	#2
Support/training services	6.7%	#2
Inkjet printers ⁴	46.6%	#1
Laser printers ⁴	43.5%	#1
Workstations ³	37.3%	#2
Notebooks ²	21.4%	#1
Desktops	16.0%	#1

Sources:

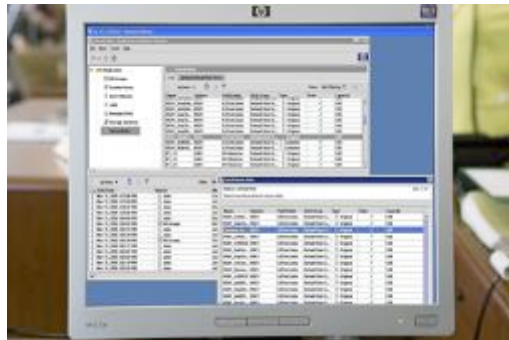
IDC June 2008 World Wide Tracker Data & IDC Worldwide Quarterly Disk Storage Systems Tracker, June 2008

IDC FY06 Annual Services and Software Data

Research & development

New ideas and new thinking

- 30,000+ technical contributors
- \$3.6B annual investment
- Company-wide R&D strategy driven by Shane Robison and Office of Strategy and Technology
- Business groups enhance core products, services and customer experiences
- HP Labs innovates “beyond” the roadmaps



HP Completes EDS Acquisition

- \$13.9B transaction is largest ever in IT services, second-largest in technology sector
- Services company with FY2007 annual collective revenue of \$38B
- 210,000+ services employees in 80 countries¹

¹Aggregate figure in combined services businesses at year-end fiscal 2007

For those countries that require consultation with works councils and other employee representatives in relation to the local implementation of the merger, this document is not intended to provide country-specific information, and in no way reflects final decisions at a local level. Where required by law, final decisions will be subject to prior consultation with works councils and other employee representatives

HP + EDS

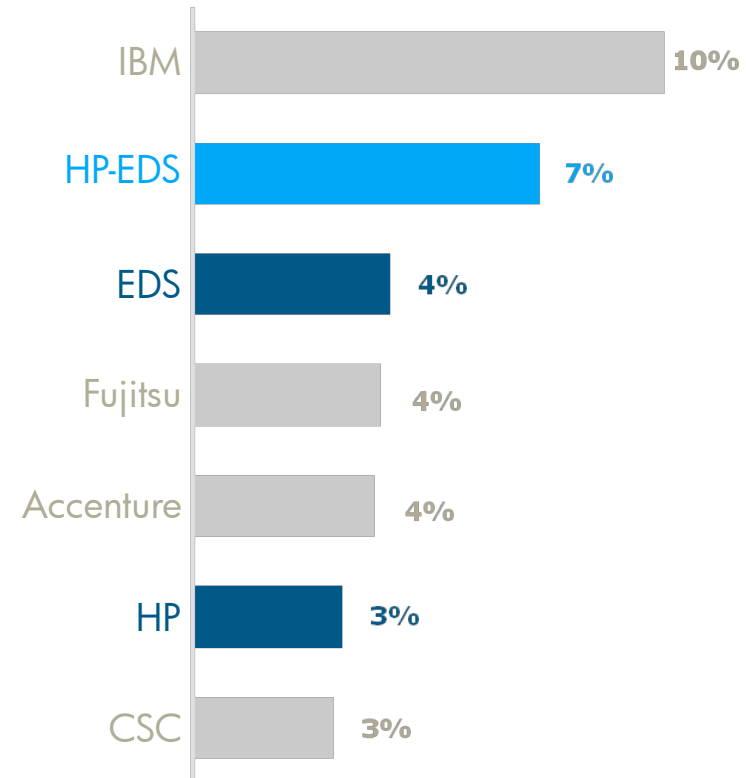
The game has changed.

#1 in Technology Hardware
#1 in Distributed Management Software

#2 in IT Services Globally
#2 in Infrastructure Technology Outsourcing
#2 in Application Outsourcing

The opportunity is compelling.

IT Services
Estimated Addressable Market (2007): \$500B - \$550B



HP: Largest Technology Company in the World

Source: IDC; Gartner's April 2008 IT Services Market Metrics Worldwide Market Share

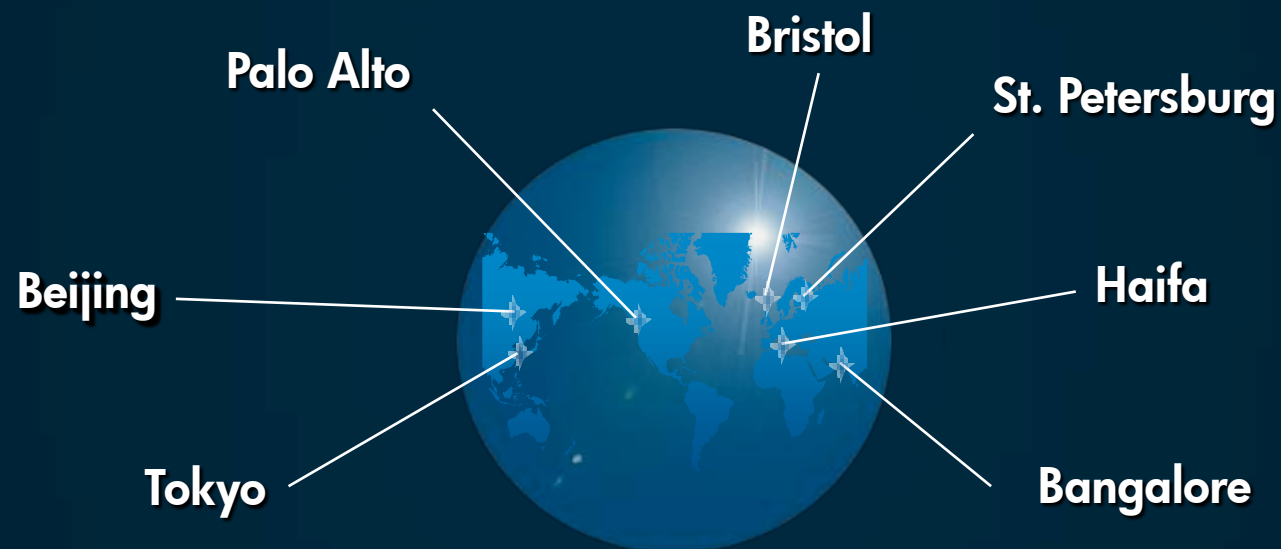
HP Labs: HP's central research organization

- HP strategy creation
- Strategically aligned technologies
- New opportunities for HP
- Fundamental science



HP Labs around the world

5 research themes with 20-30 projects at a time



7 locations

600 researchers in 23 newly
formed labs

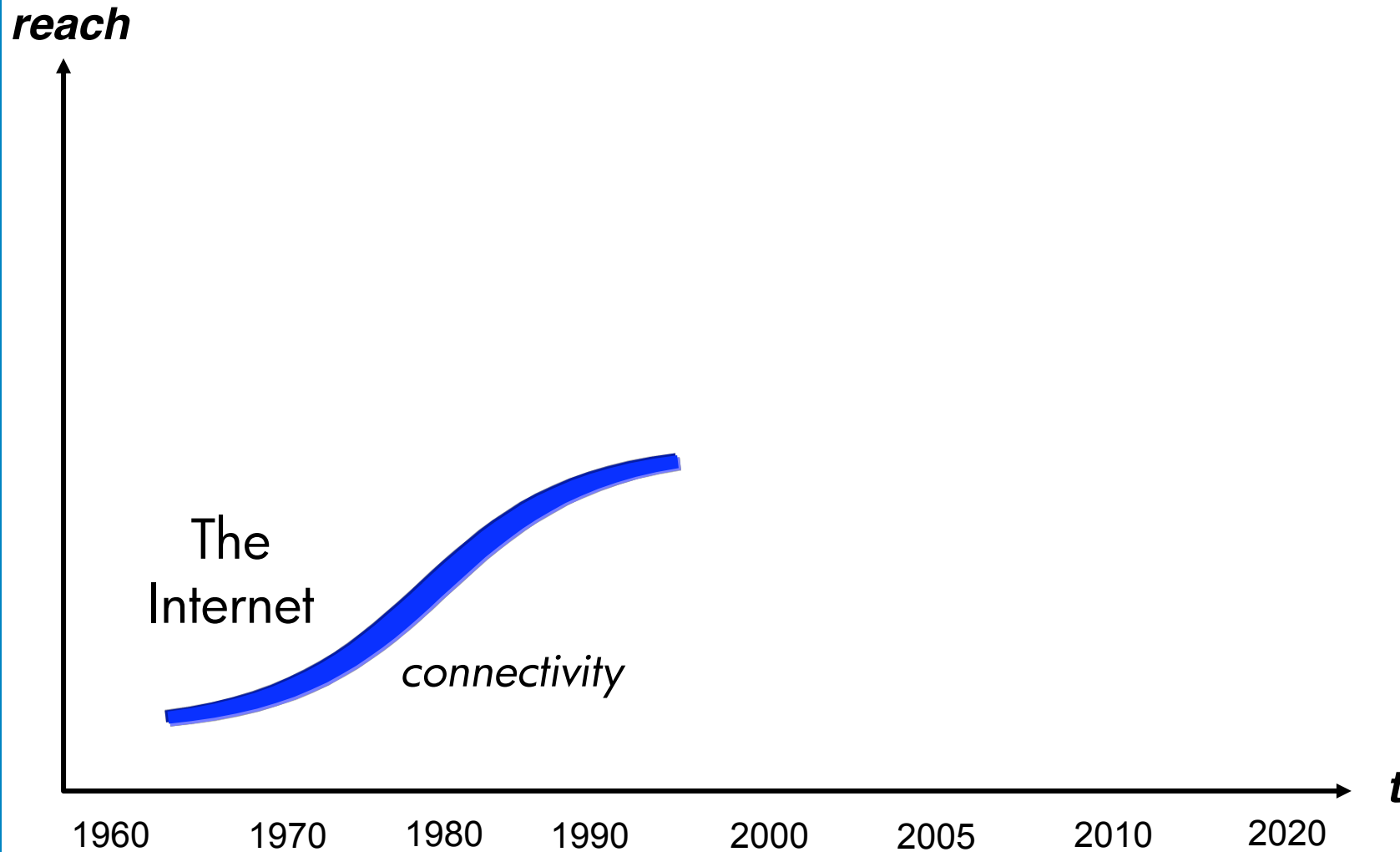
High impact research themes

Addressing the next technology challenges and opportunities



Evolution to the Cloud

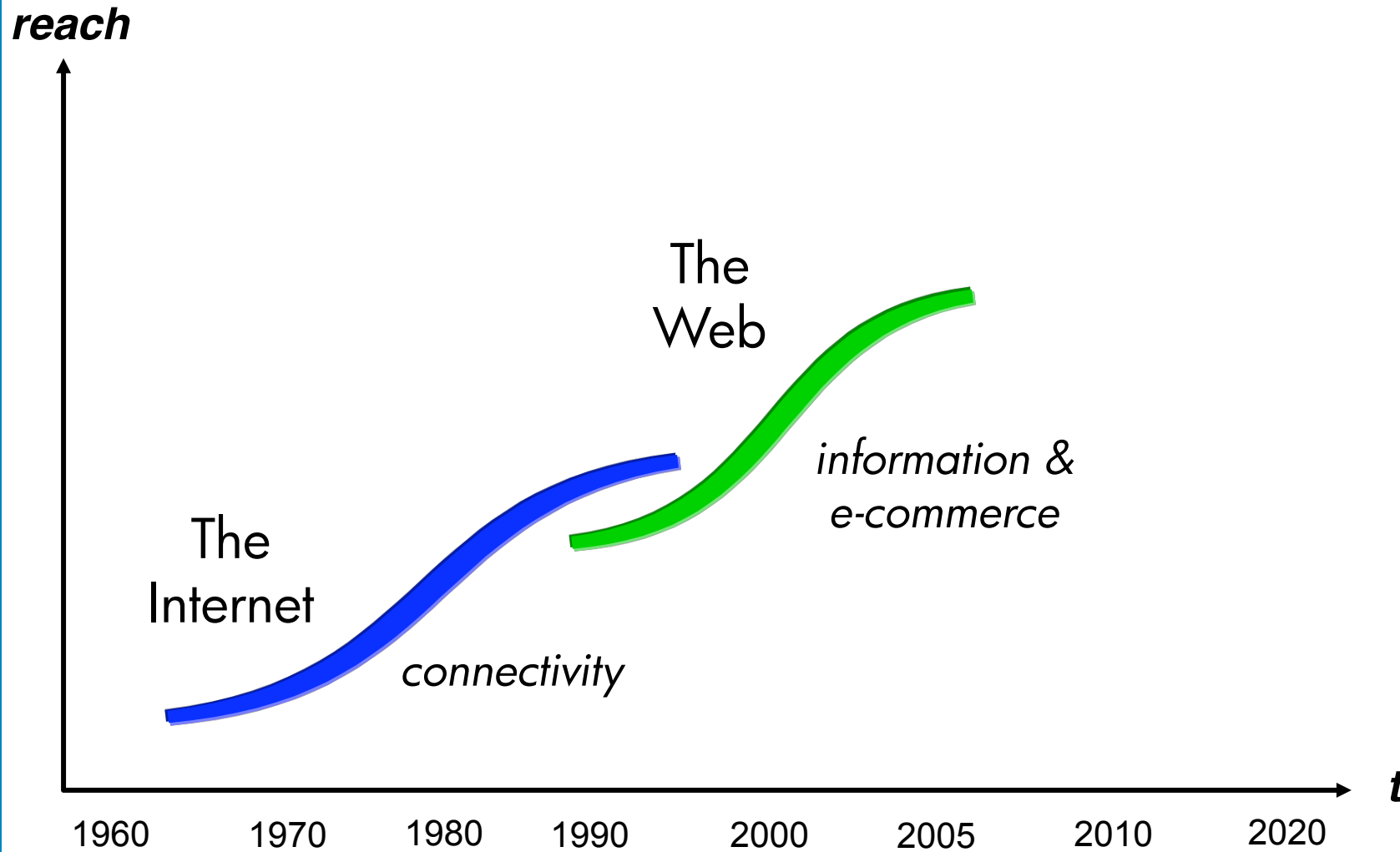
The First Generation



Stage 1: The Internet: Connectivity



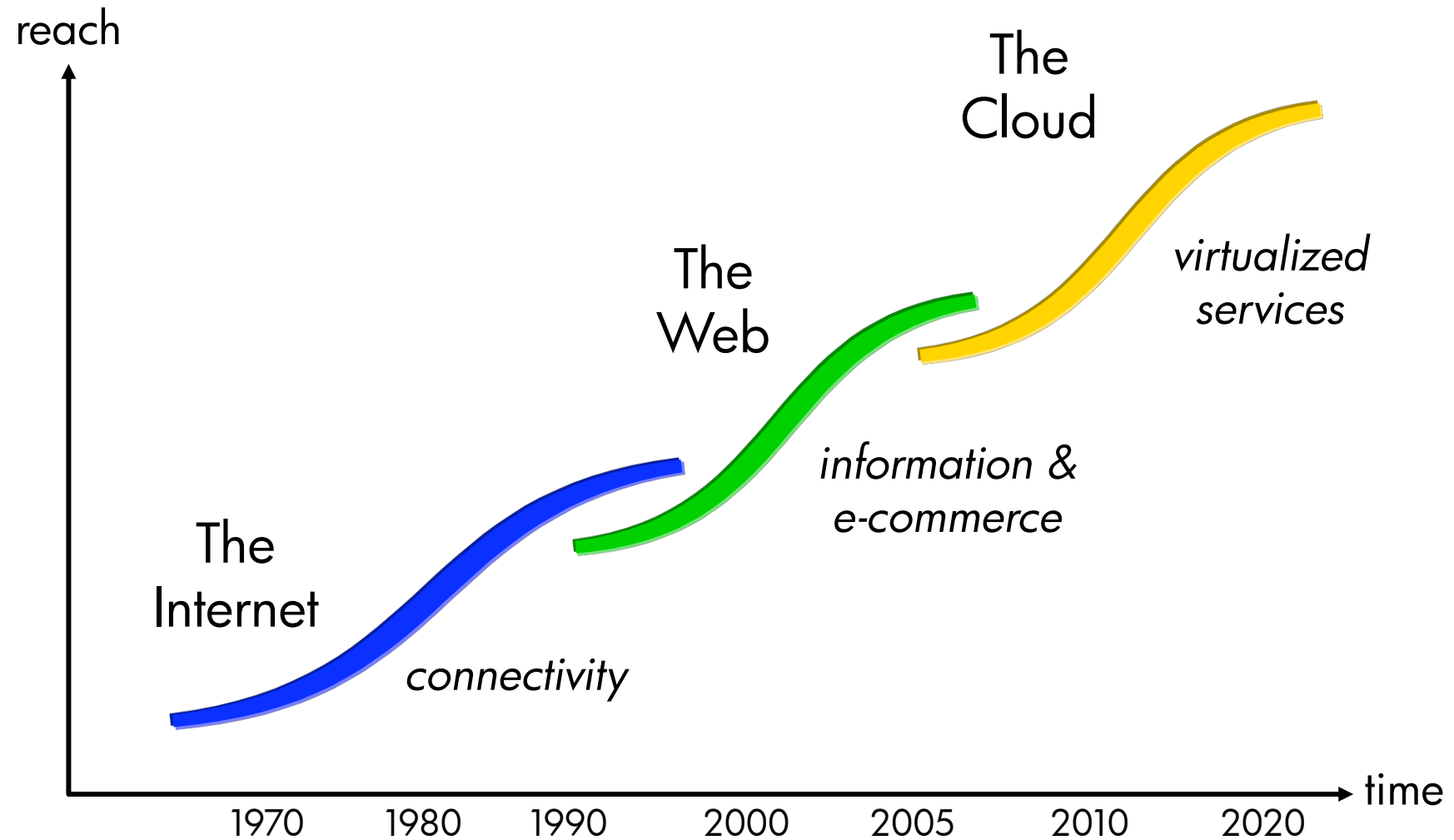
The Second Generation



Stage 2: The Web: Information



The Third Generation



Stage 3: The Cloud: Services



So, What is Cloud Computing?

The 451 Group: “The cloud is IT as a Service, delivered by IT resources that are independent of location”

Gartner: “Cloud computing is a style of computing where massively scalable IT-related capabilities are provided ‘as a service’ across the Internet to multiple external customers”

Forrester: “A pool of abstracted, highly scalable, and managed infrastructure capable of hosting end-customer applications and billed by consumption”

A Real Trend or a Marketing Bandwagon?

- **Both:**
- A useful, evocative way of talking about a big shift in IT delivery and consumption
- There won't be a precise definition
- There will be many abuses of the term

A Confluence of Technologies and Ideas

- Grid computing, utility computing, virtualization, SOA
 - Direct comparisons with these technologies are 'apples and oranges' comparisons (or fruitless 😊) ...
- ... because Cloud computing is a conceptual service model, where:
 - Services are delivered remotely from a logical resource
 - The details behind the scenes are hidden; may use the techs. above
 - Are paid for based on how much service is consumed
 - Are genuinely on-demand
- Cloud computing is a real trend driven by
 - The ubiquity of internet connectivity
 - Low-cost commodity hardware and open source software
 - Figuring out a bunch of technical stuff

And ...

- At Internet scale
 - Millions of users
- With unprecedented flexibility
 - APIs, mash-ups and other integrations, scaling up and down, ...
- At breakthrough cost levels
 - Economies of scale
 - New revenue models
 - Eliminating old sources of cost (SaaS vs. CD)

Inside the Cloud



Google in 1997

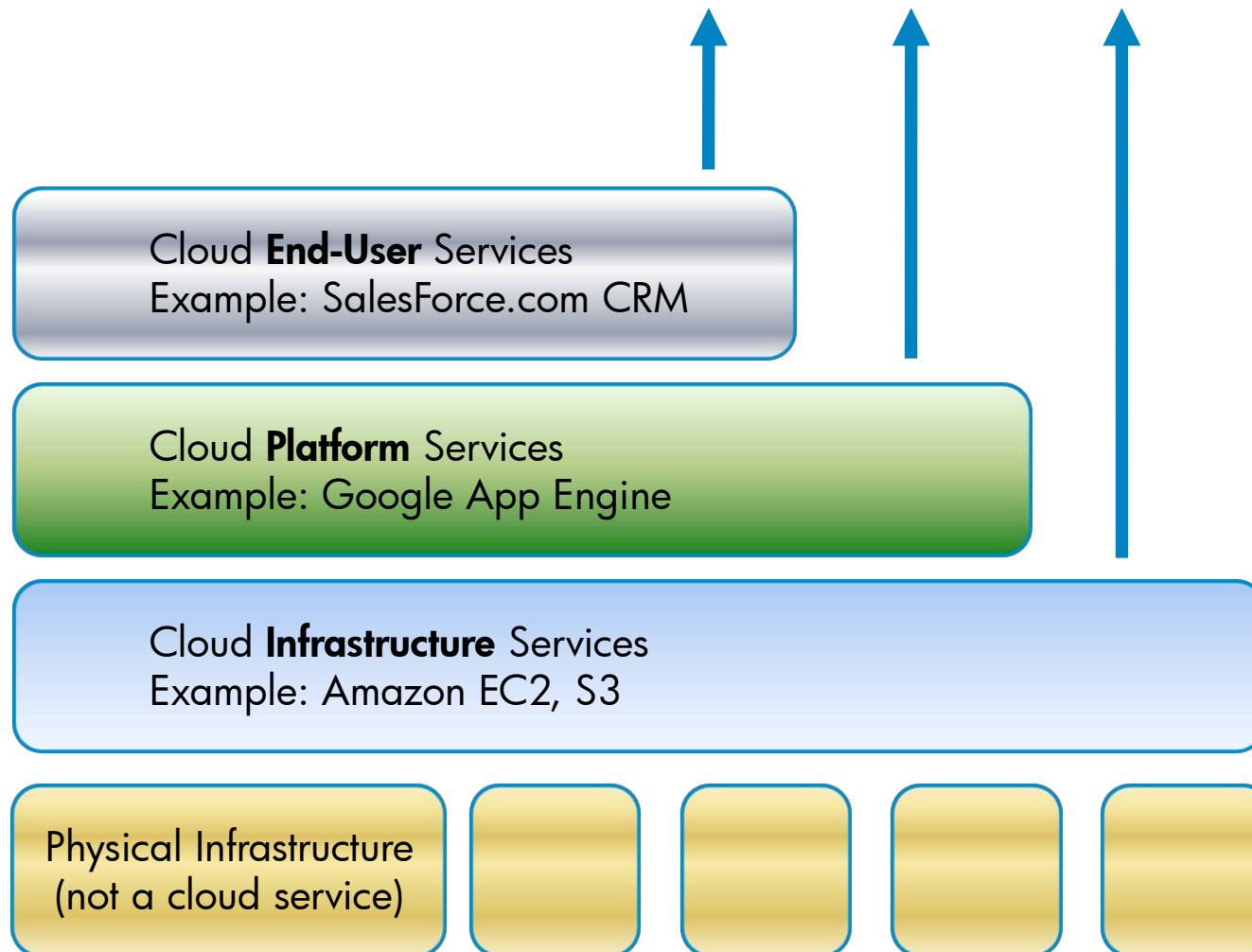


Google in 2007

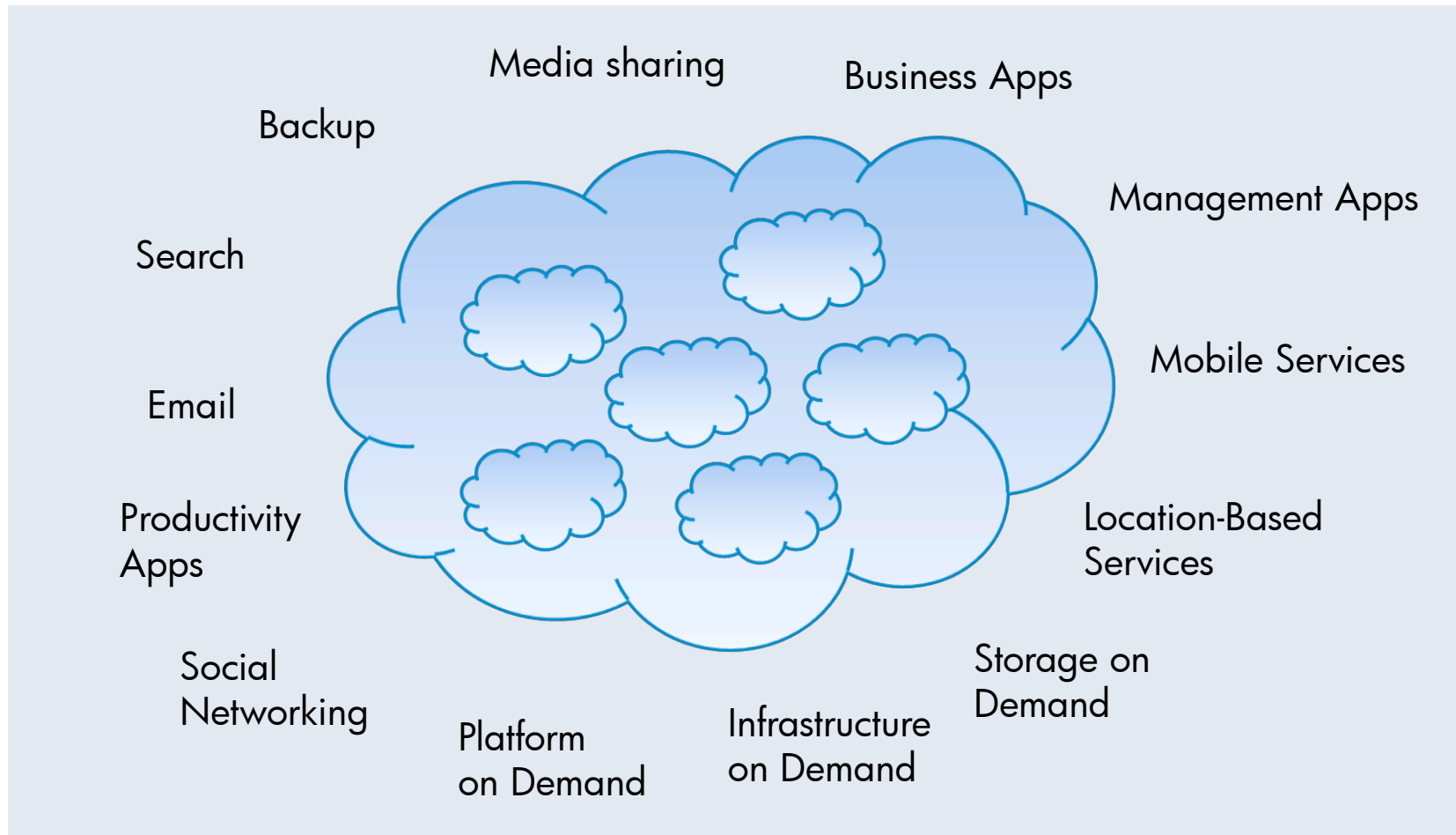
- 36 data centers containing > 800K servers
- 40 servers/rack
- Custom hardware, customized Linux base OS, lots of homebrew s/w
- Gobbling up dark fibre

- Many unreliable servers to fewer high cost servers
- Single search query touches 700 to up to 1k machines in < 0.25sec
- Typical H/W failures: Install 1000 machines and in 1 year you'll see: 1000+ HD failures, 20 mini switch failures, 5 full switch failures, 1 PDU failure
- There are more than 200 Google File System clusters
- The largest BigTable instance manages about 6 petabytes of data spread across thousands of machines

Cloud Service Layers



IT as a Service, Delivered by Cloud(s)



15 Ways to Tell it's **not** a Cloud

- If you peel back the label and it's says "Grid" or "OGSA" underneath... it's not a cloud
- If you need to send a 40 page requirements document to the vendor then... it's not cloud
- If you can't buy it on your personal credit card... it's not a cloud
- If they are trying to sell you hardware... it's not a cloud.
- If there is no API... it's not a cloud.
- If you need to re-architect your systems for it... it's not a cloud.
- If it takes more than ten minutes to provision... it's not a cloud
- If you can't de-provision in less than ten minutes... it's not a cloud
- If you know where the machines are... it's not a cloud
- If there is a consultant in the room... it's not a cloud
- If you need to specify the number of machines you want upfront... it's not a cloud
- If it only runs one operating system... it's not a cloud
- If you can't connect to it from your own machine... it's not a cloud
- If you need to install software to use it... it's not a cloud
- If you own all the hardware... it's not a cloud

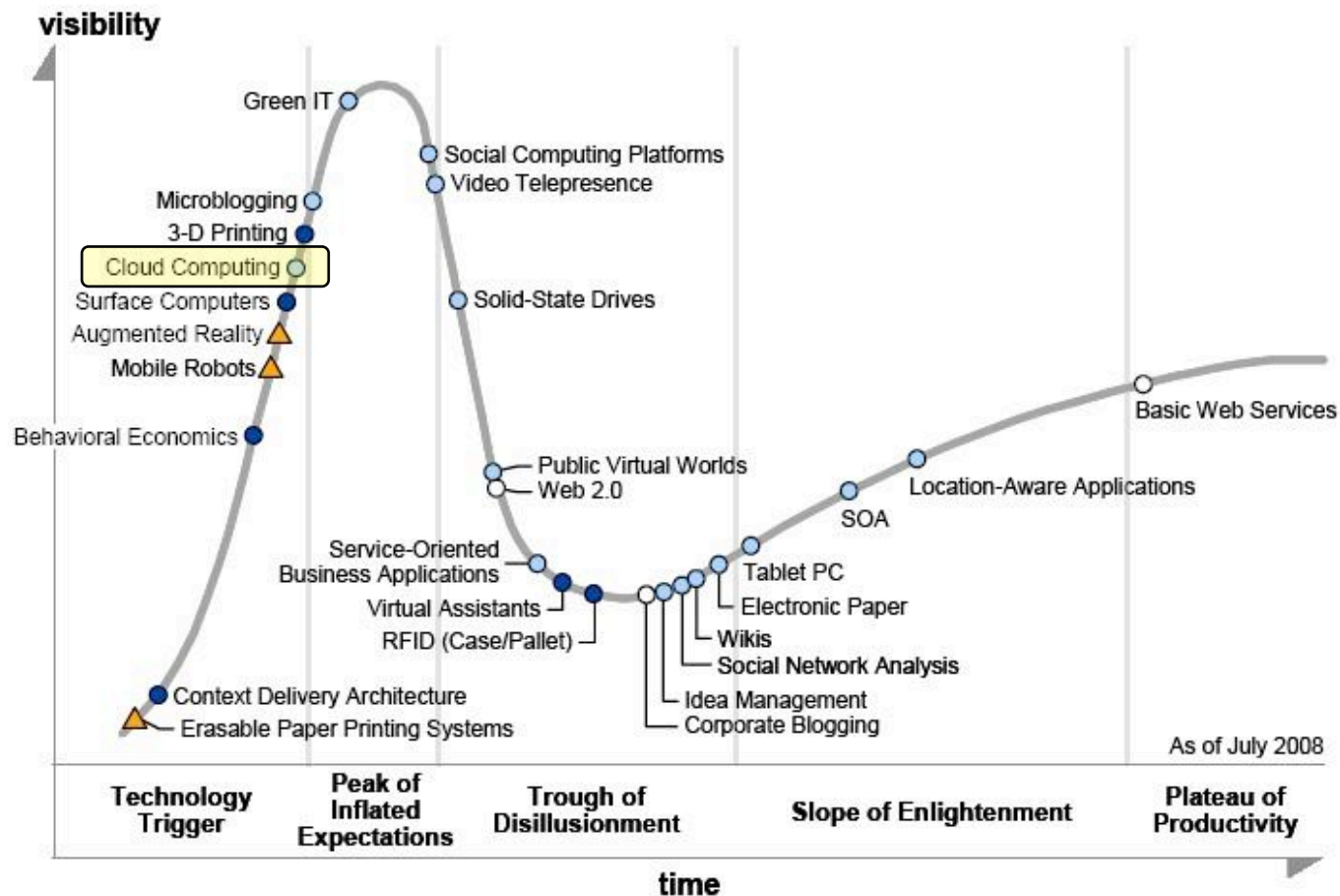
James Governor, Redmonk

Why Cloud Computing?

- Cost reduction
 - Benefit from economies of scale
 - Predictability of spend
 - Avoids cost of over-provisioning
 - Reduction in up-front investment
- Risk reduction
 - Someone else worries about running the data-centre, protecting your data, and providing DR
 - Reduces risk of under-provisioning
- Flexibility
 - Add/remove use of services
 - Scale up and down as needed
 - Do it quickly
- Service Evolution
 - Services evolve and (hopefully!) improve behind the scenes, with no user-involvement required
- Ubiquity
 - access from any place, any device, any time

Get Ready for the Hype ...

Figure 1. Hype Cycle for Emerging Technologies, 2008



Years to mainstream adoption:

○ less than 2 years

● 2 to 5 years

● 5 to 10 years

▲ more than 10 years

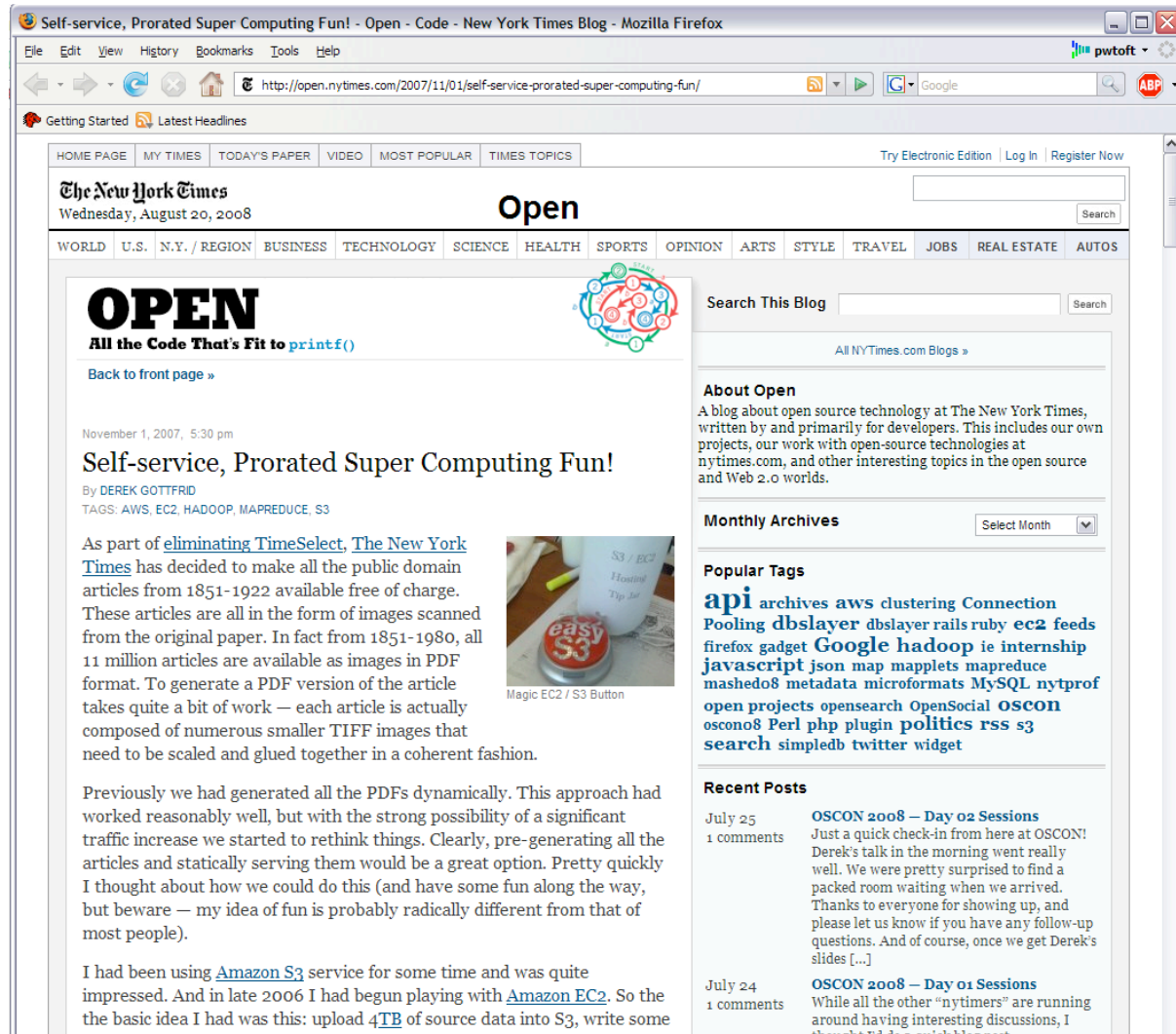
⊗ obsolete before plateau

Source: Gartner (July 2008)

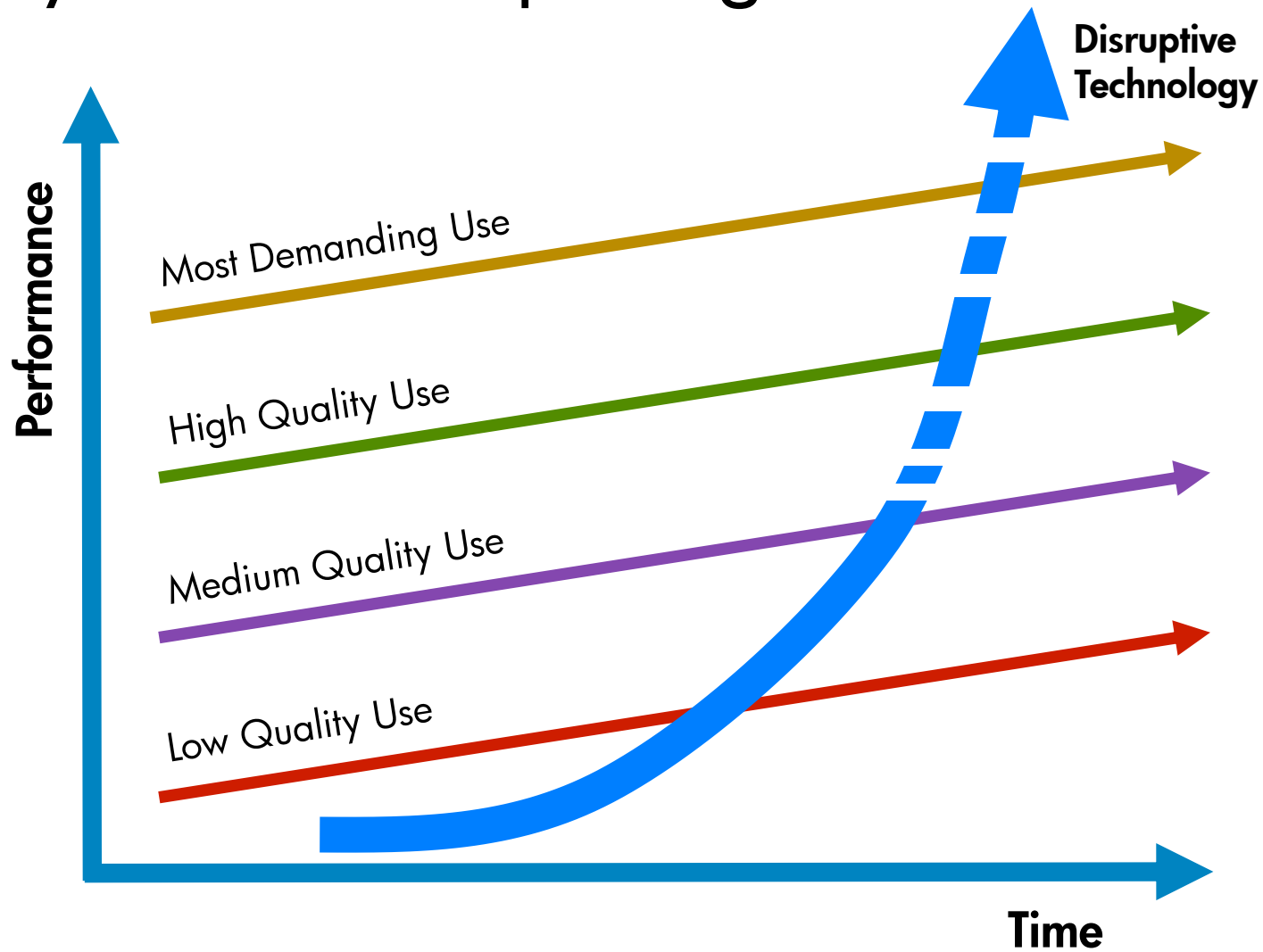
Is the Cloud Ready for the Enterprise?

- Yes, for some applications
 - Crash and burn, dev/test, batch processing, peak-load capacity expansion for some tasks
 - Some applications gaining traction
 - Often outside the control of the internal IT organisation
 - LOTS of interest
- Not for the core mission critical stuff ... yet

A Nice Example: NYT and EC2



Why is this Compelling?



Barriers to Adoption

- **Security**
- Trust in the service vendor
 - Service levels
 - Stability
 - Geographic presence
- ISV support not widespread
- Few have taken the plunge in a big way
- Customizability of service offerings for specific needs of each enterprise
- Concerns about lock-in, lack of multi-vendor options
- Data locality
- Regulatory concerns
- Challenge of migrating from in-house (or outsourced) apps
- Vested interests!

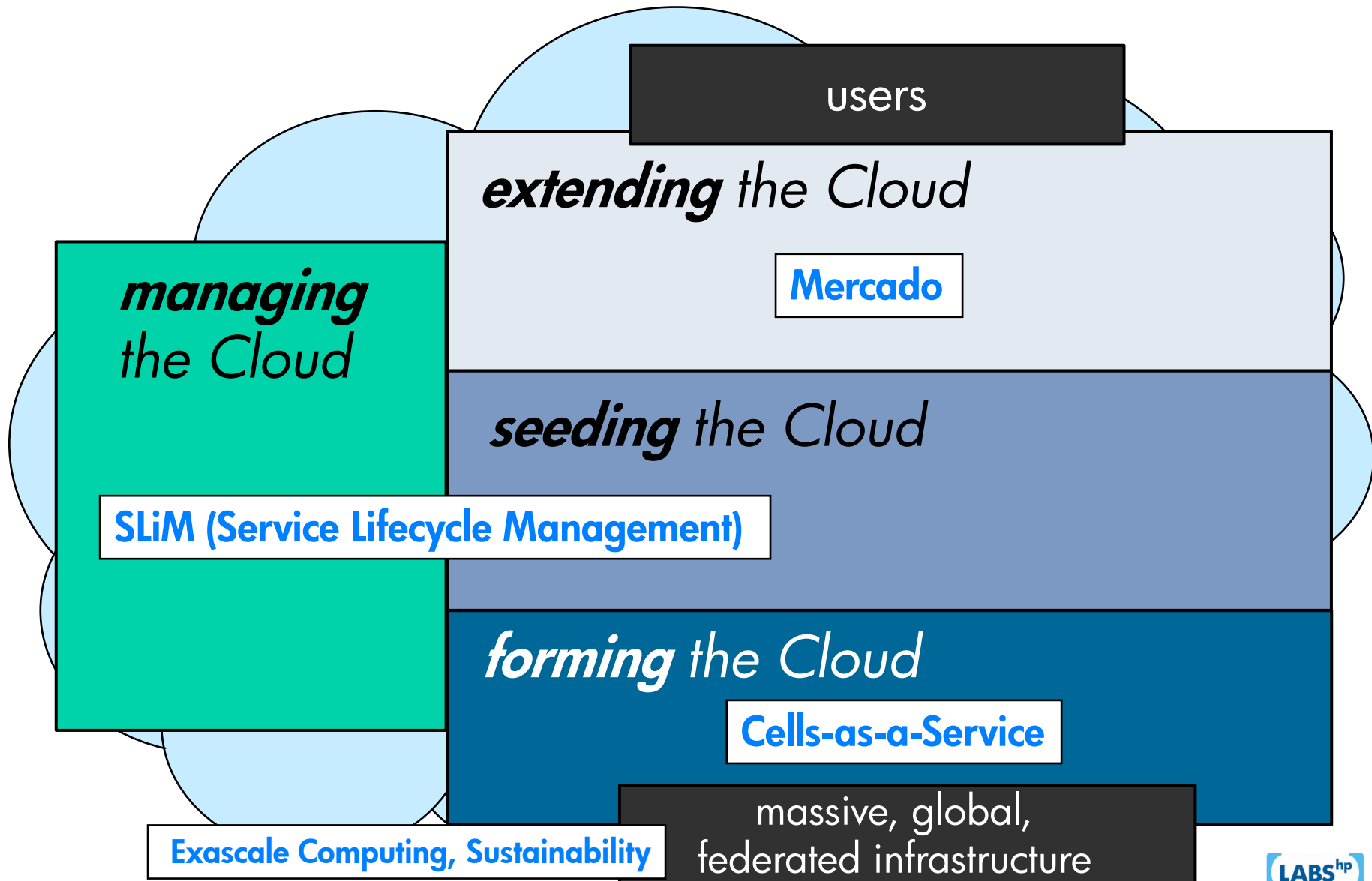
Private/Hybrid Clouds

- The Enterprise Cloud: large-scale infrastructure satisfying all cloud properties, delivering services out to enterprise business units
- Hybrid Model: in-house cloud linked seamlessly to the public cloud
 - “Cloudbursting”

HP LABS RESEARCH EXAMPLE

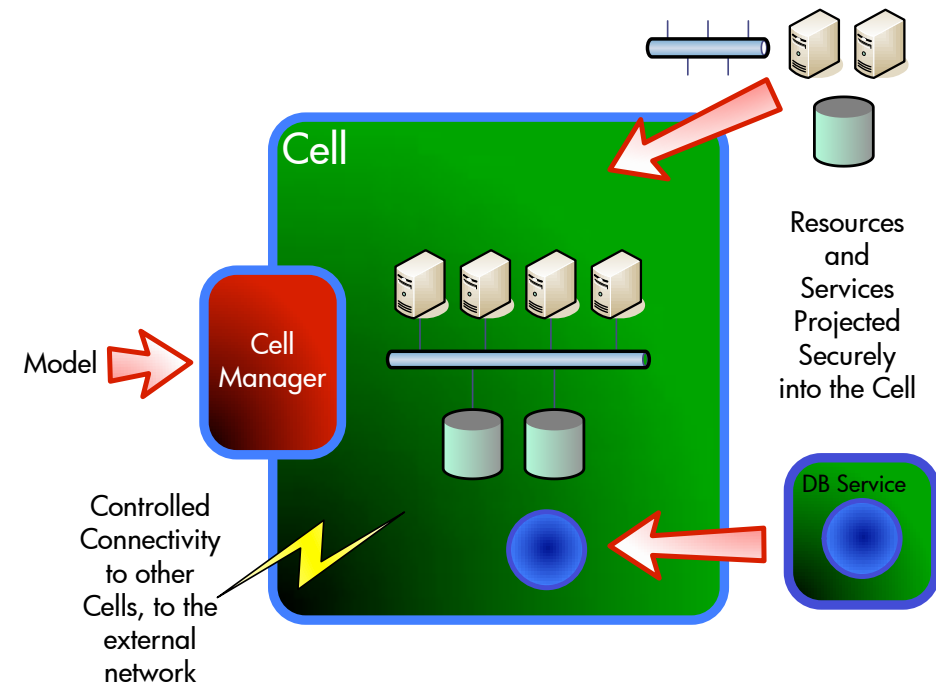
VIRTUAL INFRASTRUCTURE SERVICE

HP Labs: Cloud Research



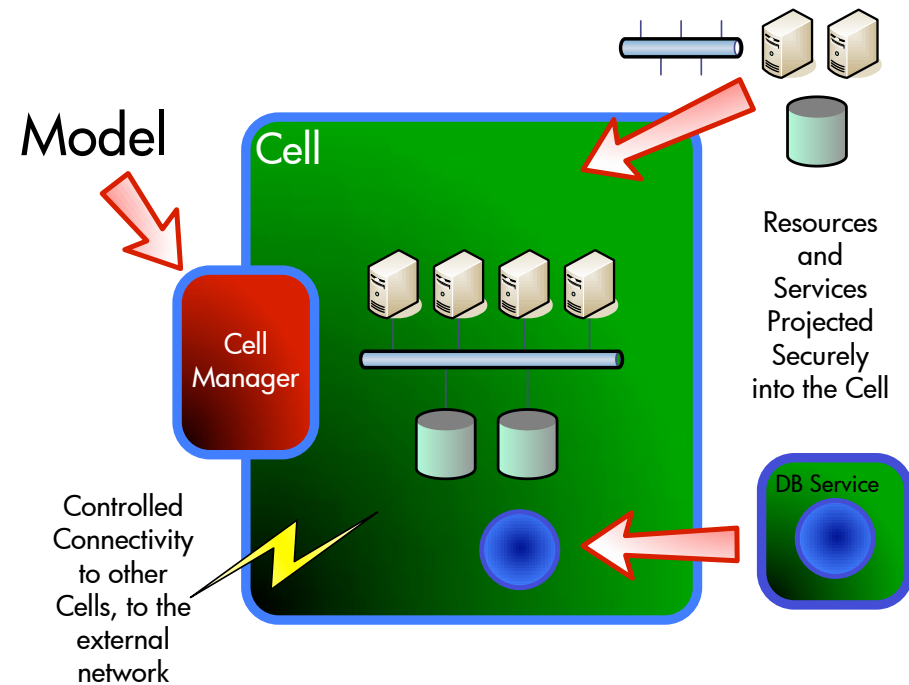
Forming the Cloud: Cells as a Service

- An infrastructure-level Cloud service
- Delivering secure, isolated virtual infrastructures – **Cells** – to multiple customers
- Offering enterprise-grade properties
- Running on large-scale physical infrastructures



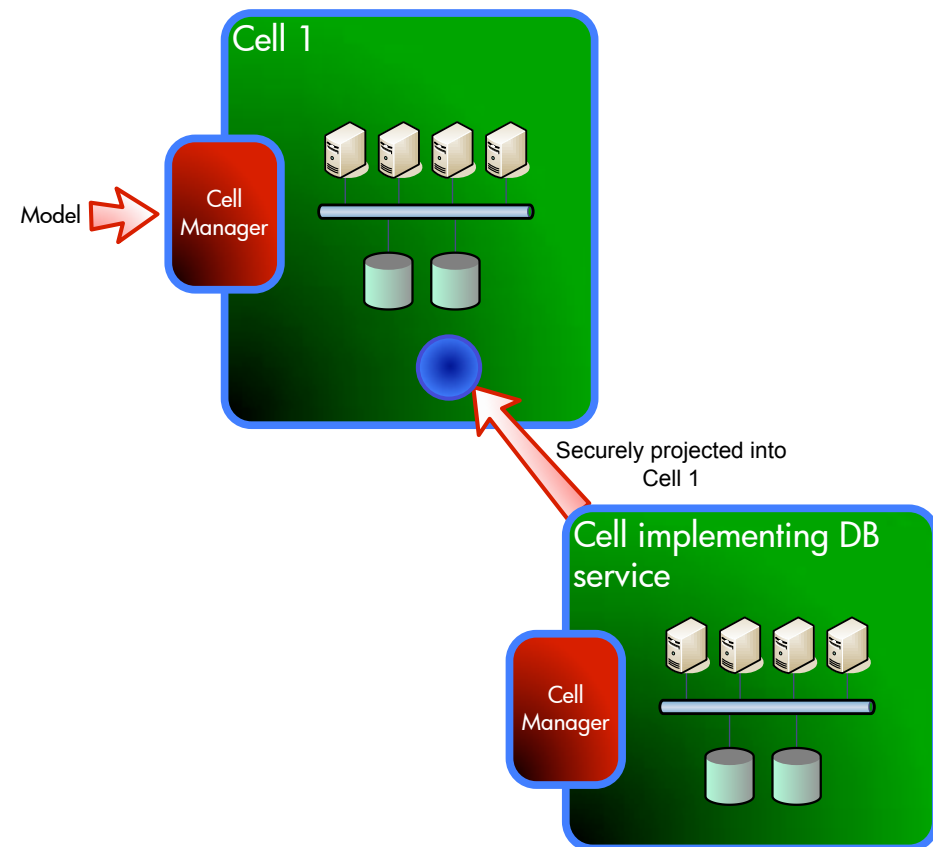
Model-Based Cell Management

- Customers interact with **Cell Managers** via bidirectional **model exchange**
- The Cell realises the resources in the model, reflects changes
- Evolution to rich model properties: adaptation, performance, ...



Cell-Based Service Composition

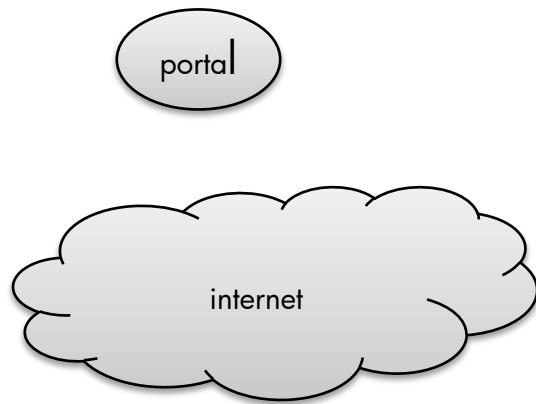
- Provide enhanced infrastructure services – beyond the 'atomic' virtual resource elements
- Service composition allows rich, Cell-based infrastructure services to be securely offered to other Cells
- Supported directly by the Cell infrastructure management system



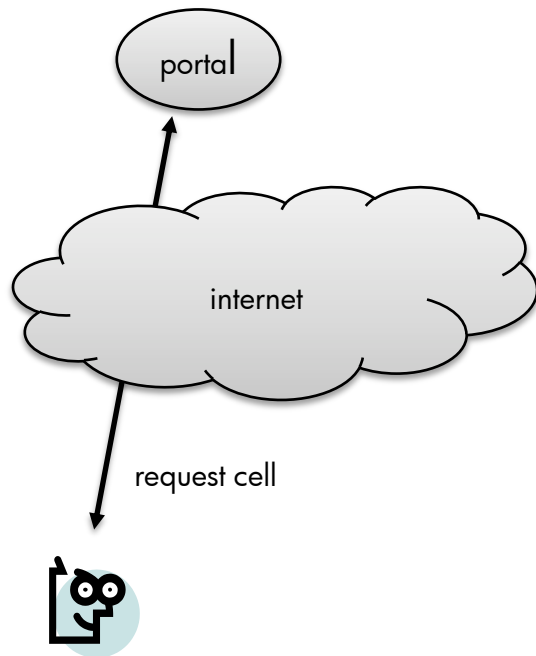
Service Composition Examples

- Encrypted Volume Service
 - A service that offers encrypted volumes to ensure that all persistent data is kept “safe”
- Replicated data service
 - Data guaranteed to be saved to multiple locations
- 3rd-party Audit Service
 - Squirrel away logs and other events securely for later audit requirements

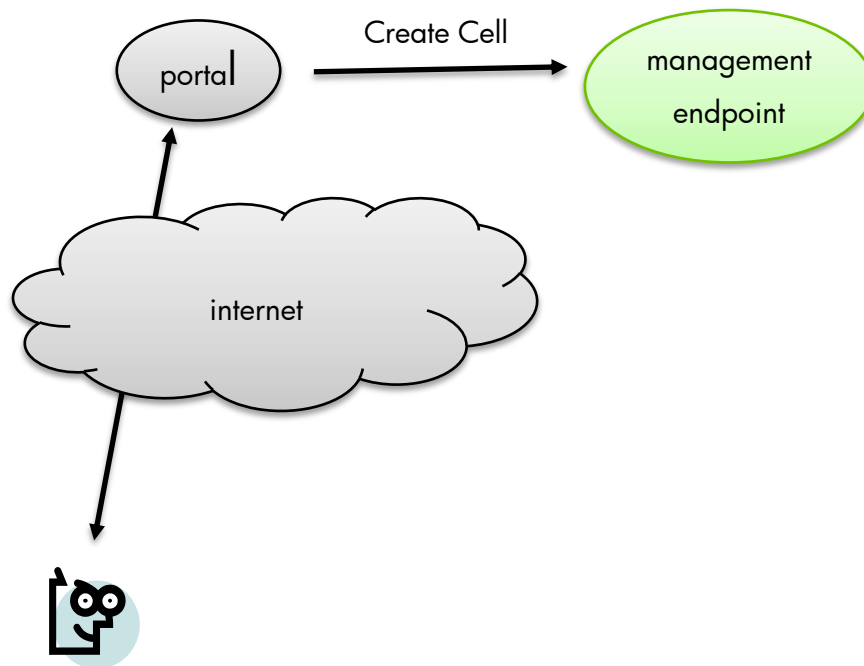
The Cell Service



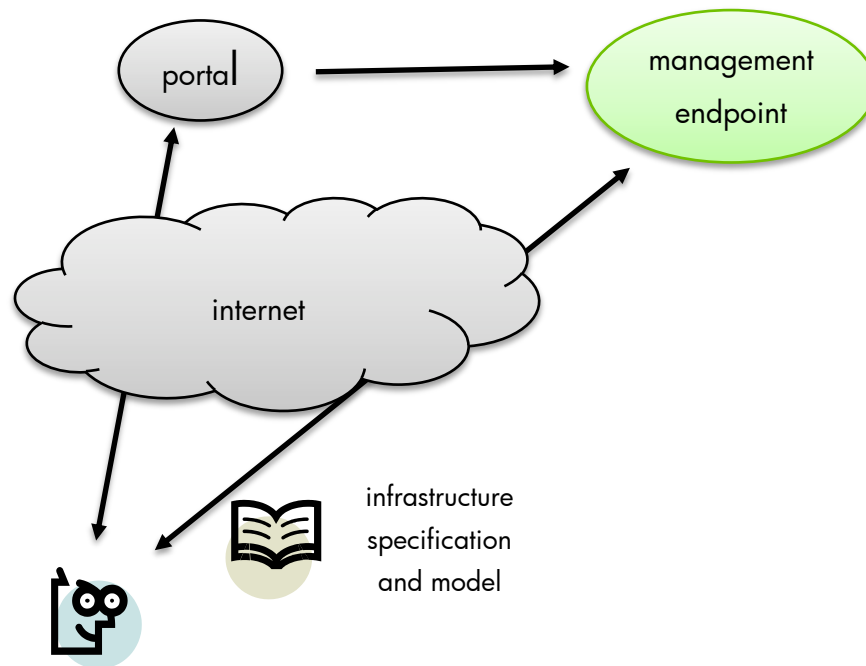
The Cell Service



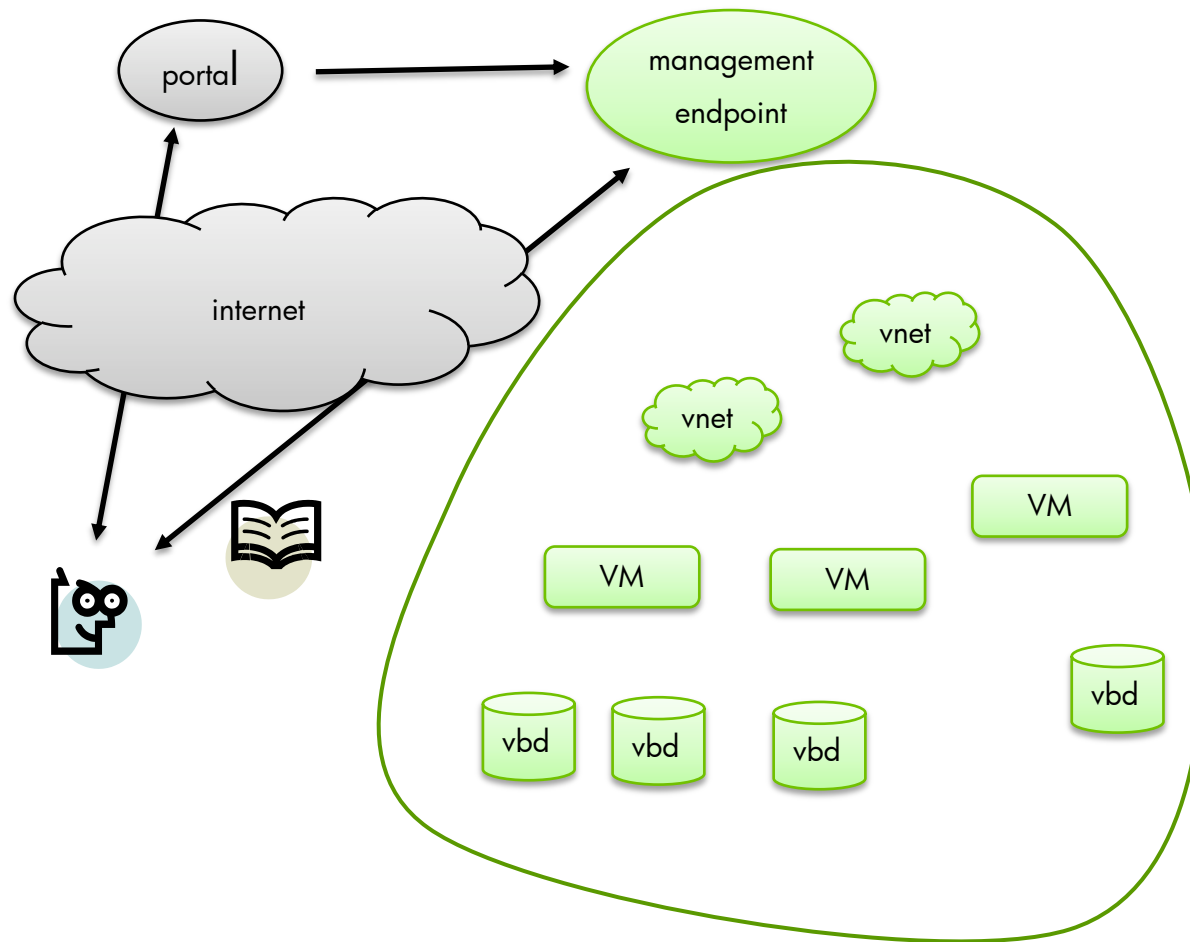
The Cell Service



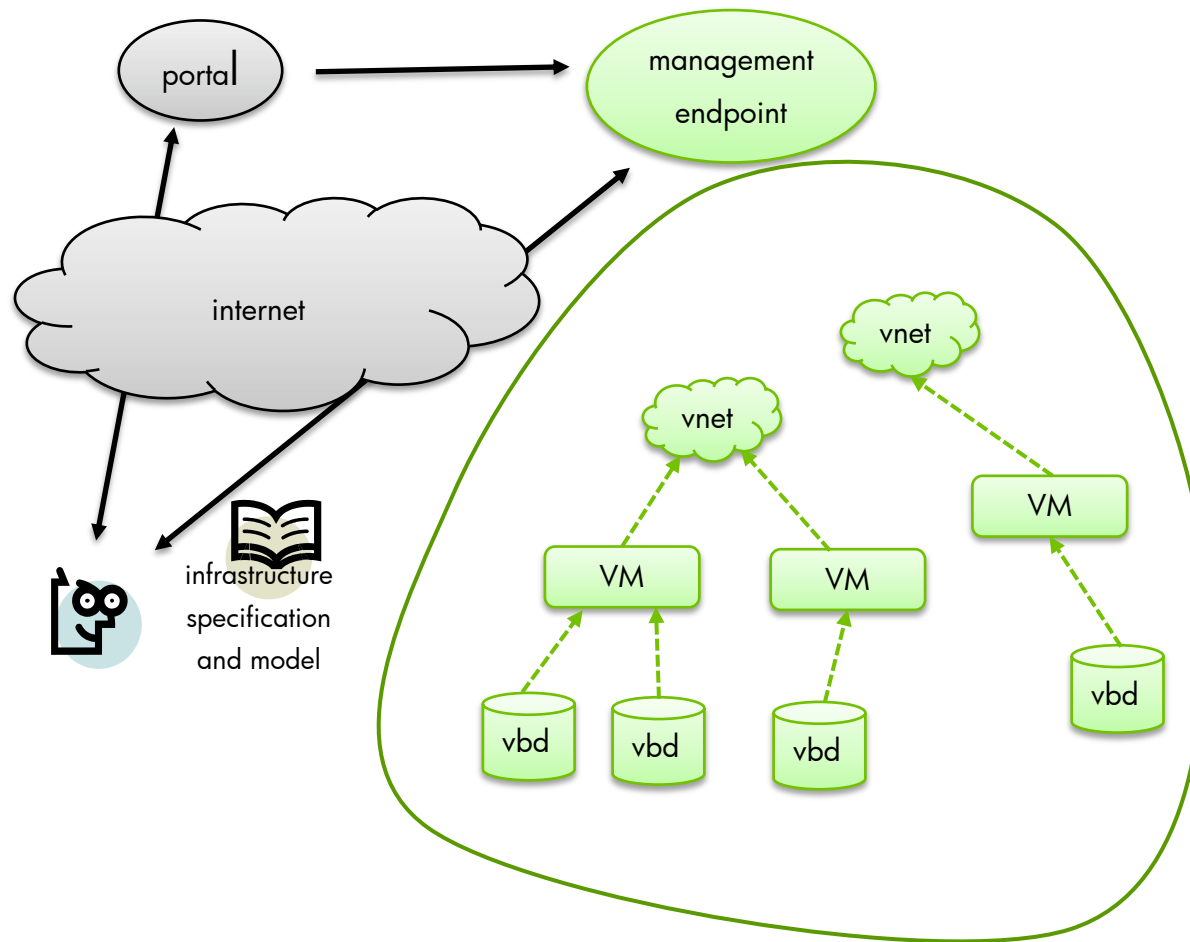
The Cell Service



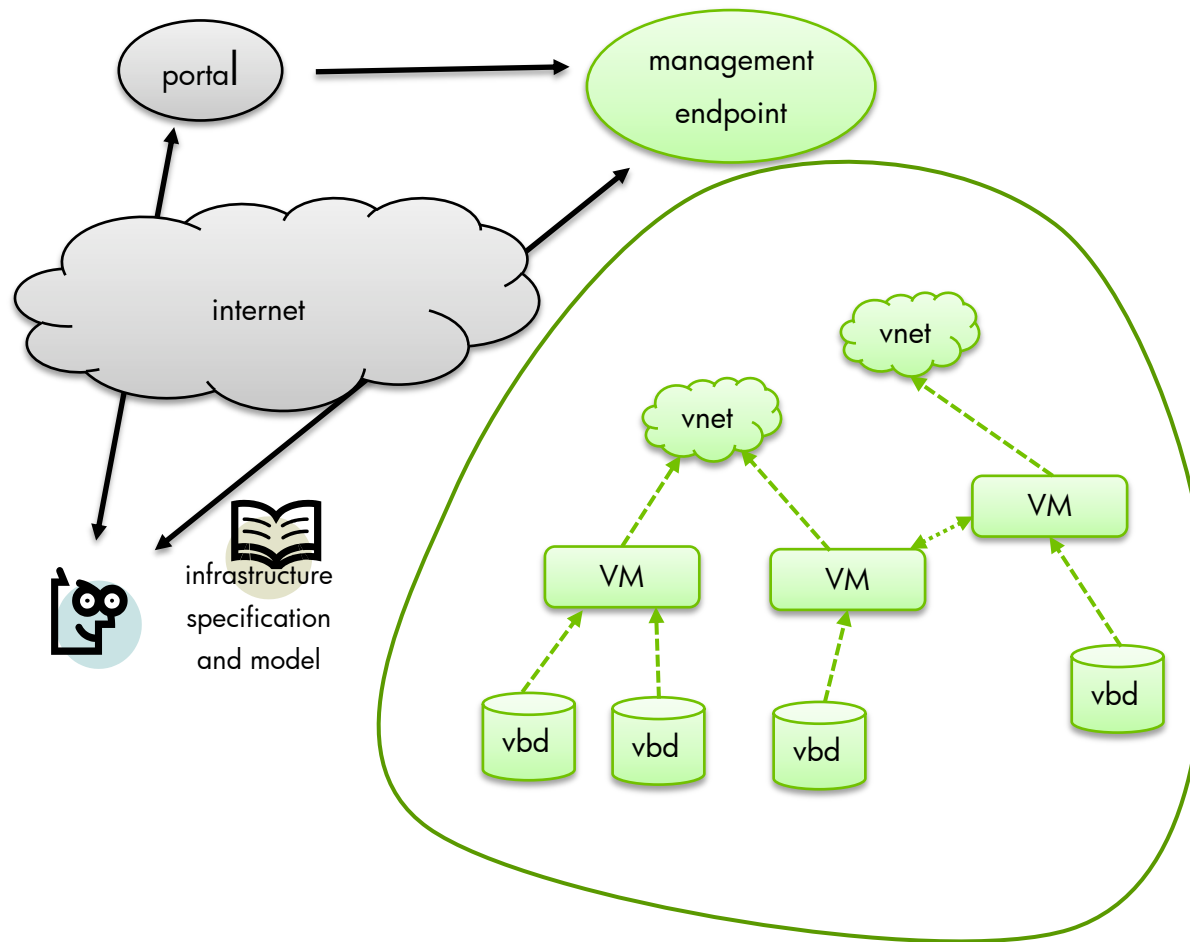
The Cell Service



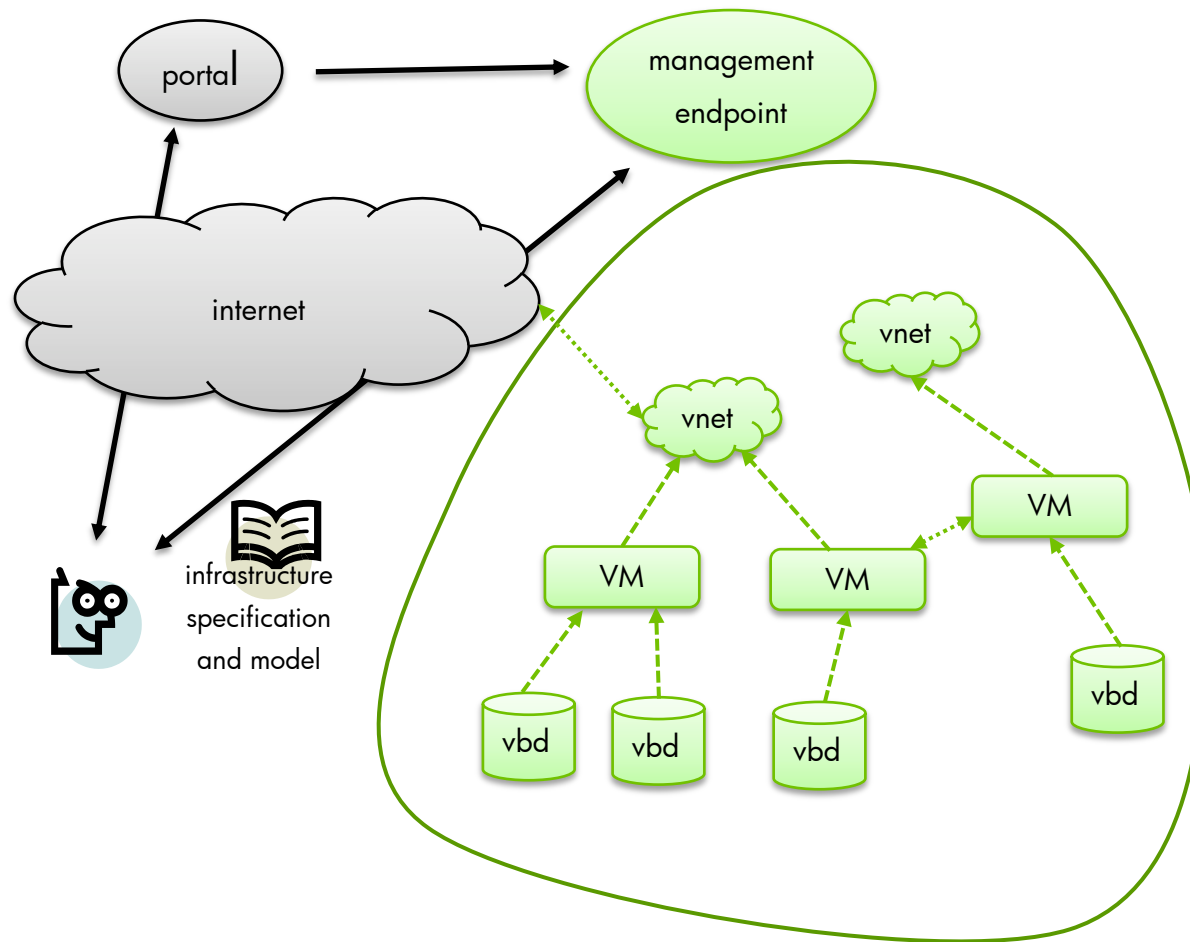
The Cell Service



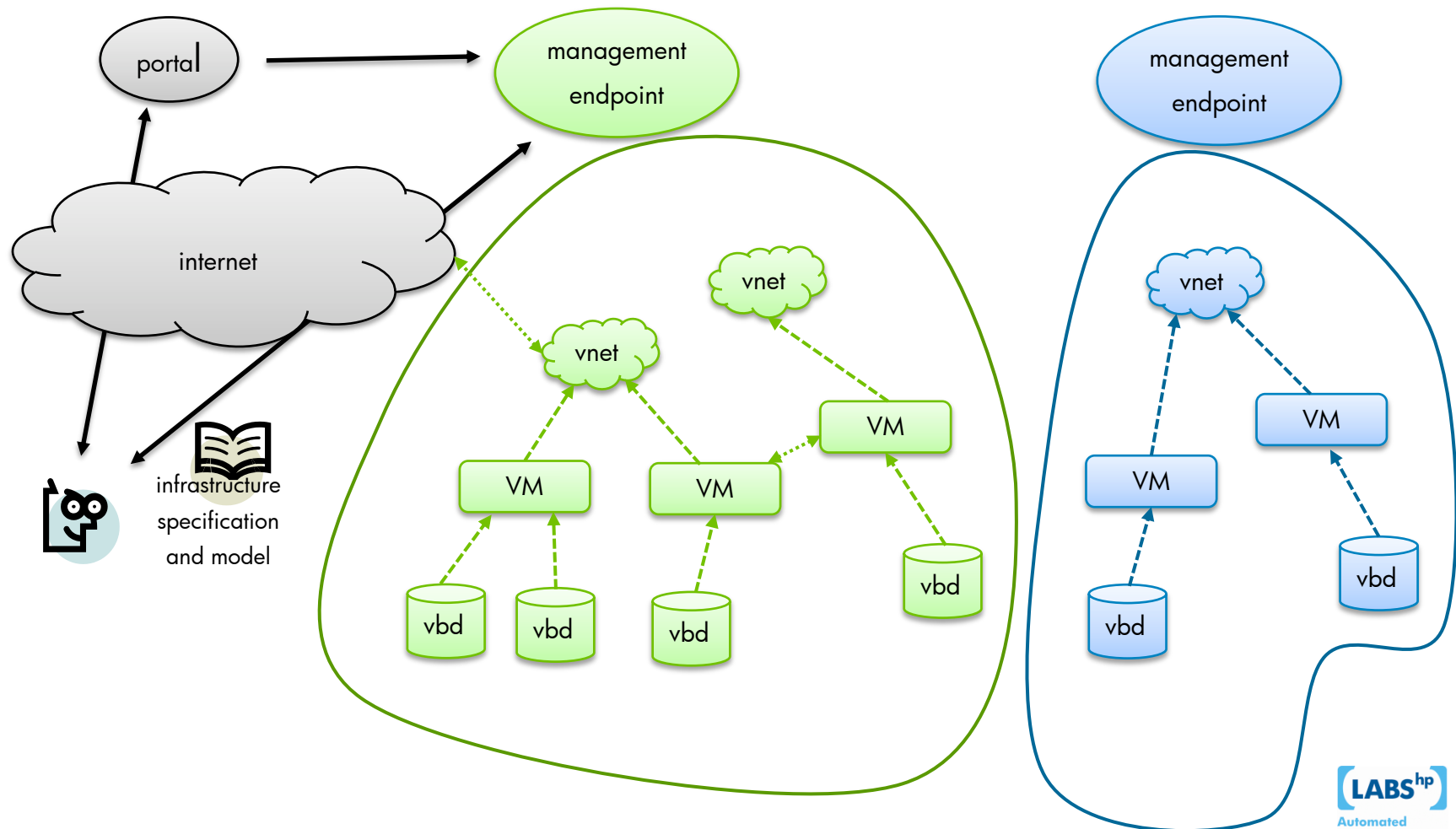
The Cell Service



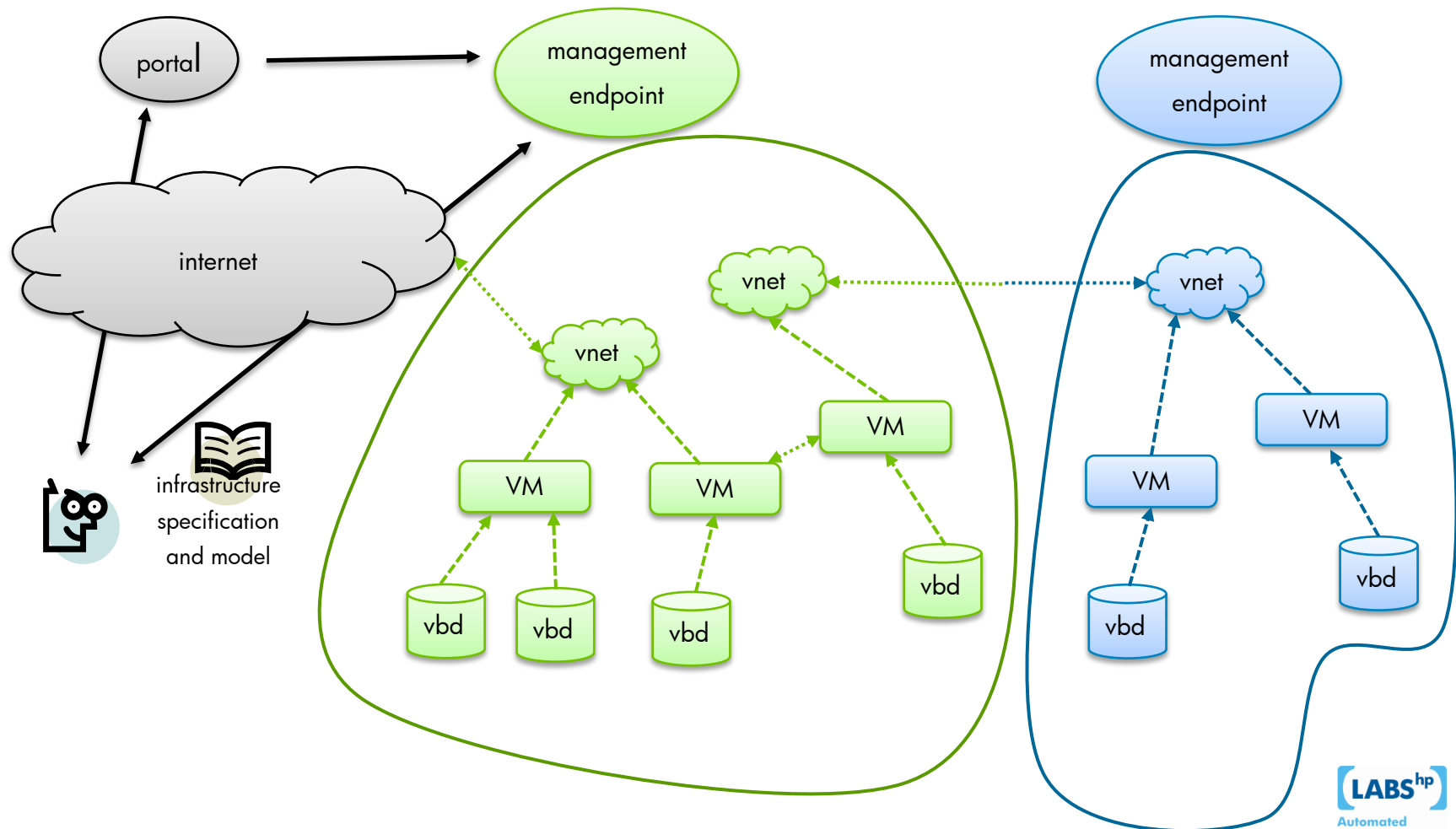
The Cell Service



The Cell Service



The Cell Service

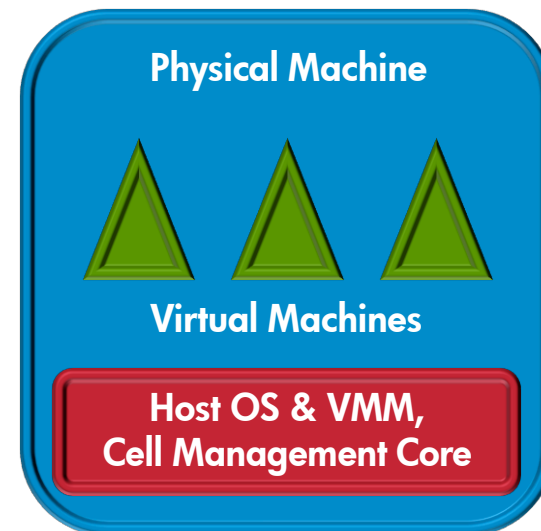


Cell Infrastructure Management System

- Design target:
 - Large-scale, commodity physical infrastructure
 - Thousands of nodes
 - Simple networking and storage
 - Commodity virtualization technology
 - Everything virtualized
 - Security at the core
 - Complete automation

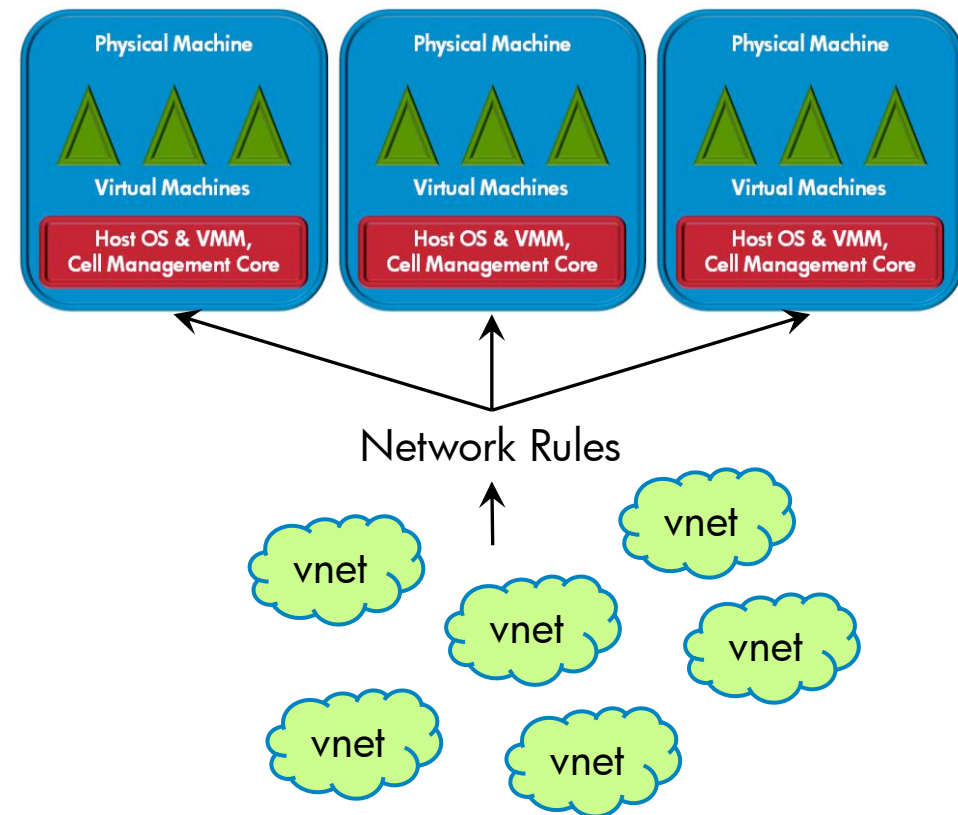
Cell Management Core

- Runs on every physical machine in the Cell infrastructure
- Controls the lifecycles of virtual machines
- Provides the fundamental 'plumbing'
 - Controls ingress and egress of network traffic between virtual machines
 - Presents storage volumes to virtual machines
- Small, correct
- All other system management functions implemented as Cell-based system services



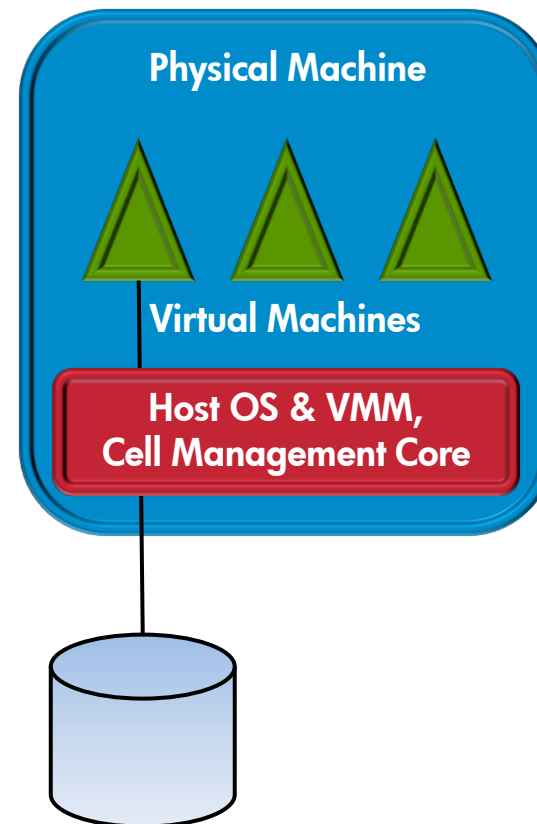
Virtual Networking

- Arbitrary connectivity can be established between virtual machines
 - Subnets within Cells
 - Connections between Cells
 - Connections to external networks
- Network rules determine which paths are allowed
 - Both ends must agree
- Network resource (rate) control
- Foundation for Cell isolation



Virtual Storage

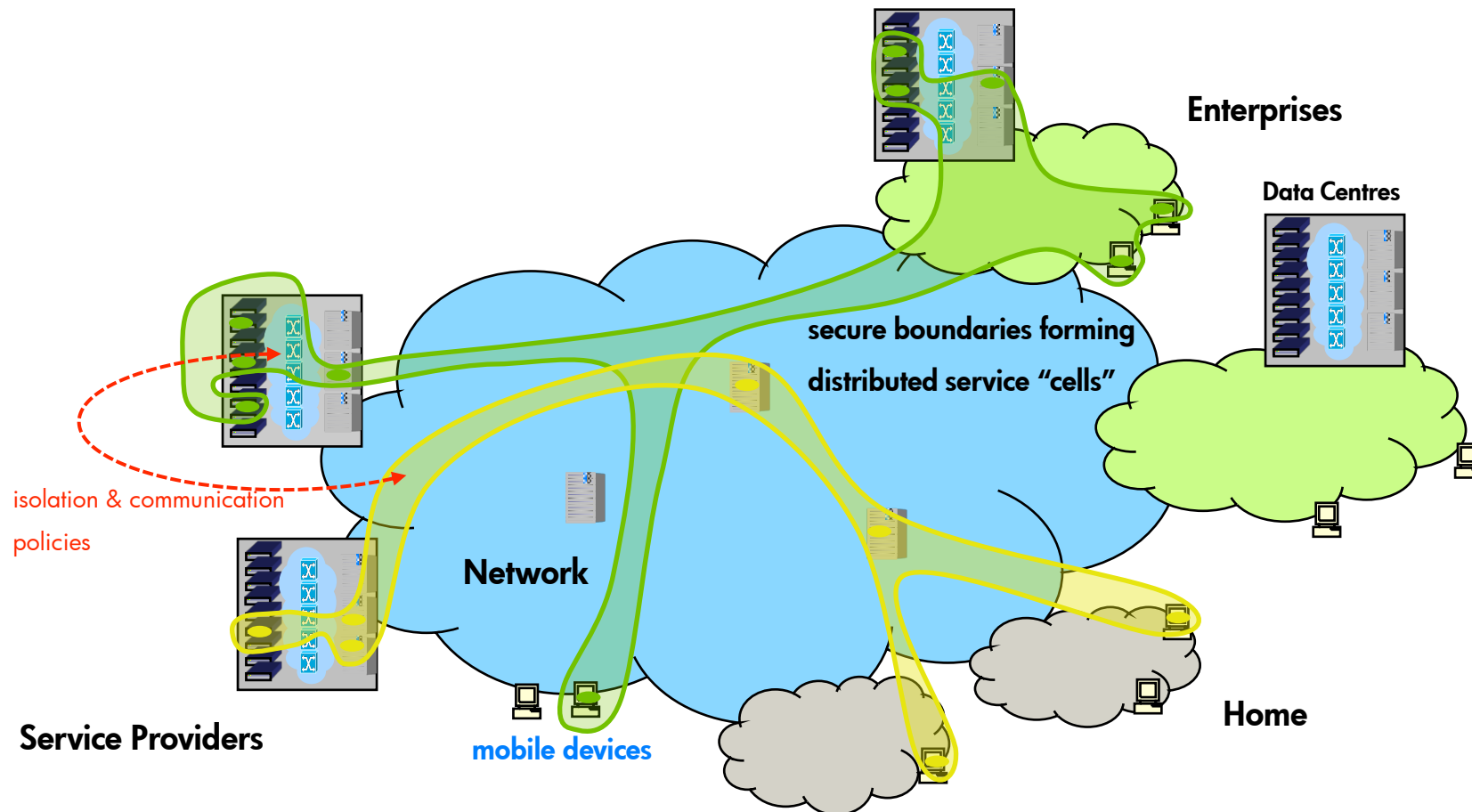
- Cell Management Core presents storage volumes to VMs
- Tricks behind the scenes:
 - Copy-on-write layers
 - Caching on local disk for volatile or read-only volumes
- Back-ended by a variety of storage technologies
 - Storage arrays
 - Distributed storage



Core System Management Services

- Running in Cells, with privileged access to the management core
- Example services:
 - Customer model transfer and processing
 - VM placement and migration
 - Network policy distribution
 - Storage management and storage policy distribution
 - Liveness
 - ...

Cells: Not Just the Data Centre



HP/Intel/Yahoo! Global Cloud Computing Research Test-Bed



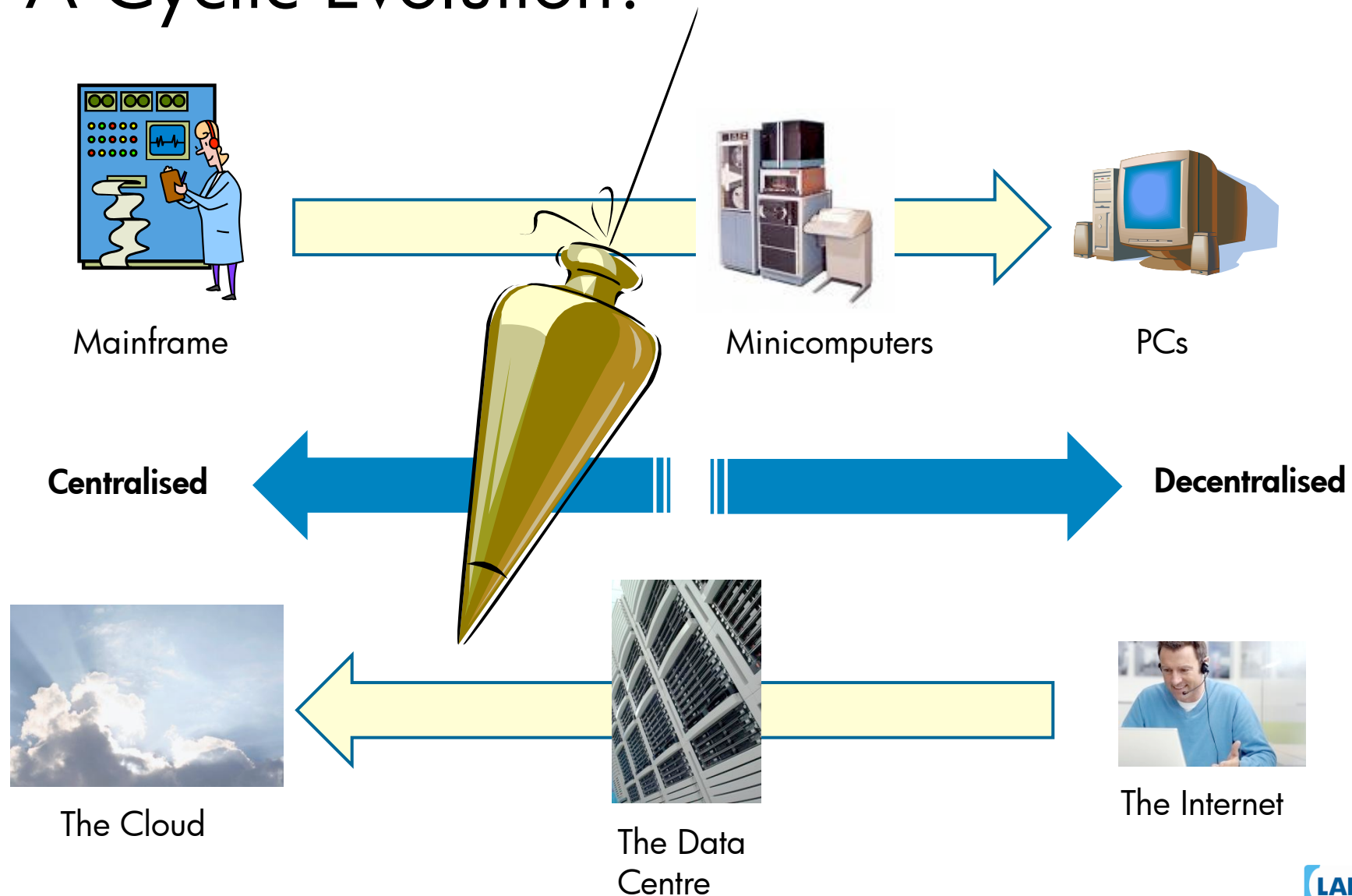
- Sponsors:
 - HP Labs, Intel Research, Yahoo! Research
- Partners:
 - IDA Singapore
 - Karlsruhe Institute of Technology
 - University of Illinois at Urbana Champaign
- Collaborative, open research on management of Cloud Computing data-centres and applications
- A shared, large-scale, distributed test-bed

Beyond the Cloud: What comes next?

'Prediction is very difficult, especially about the future.'

Niels Bohr

A Cyclic Evolution?



Mesh Networks of Connected Devices 'Plasma Computing'?

