

# Emerging, Dynamic Distributed Systems and Challenges for Services Engineering

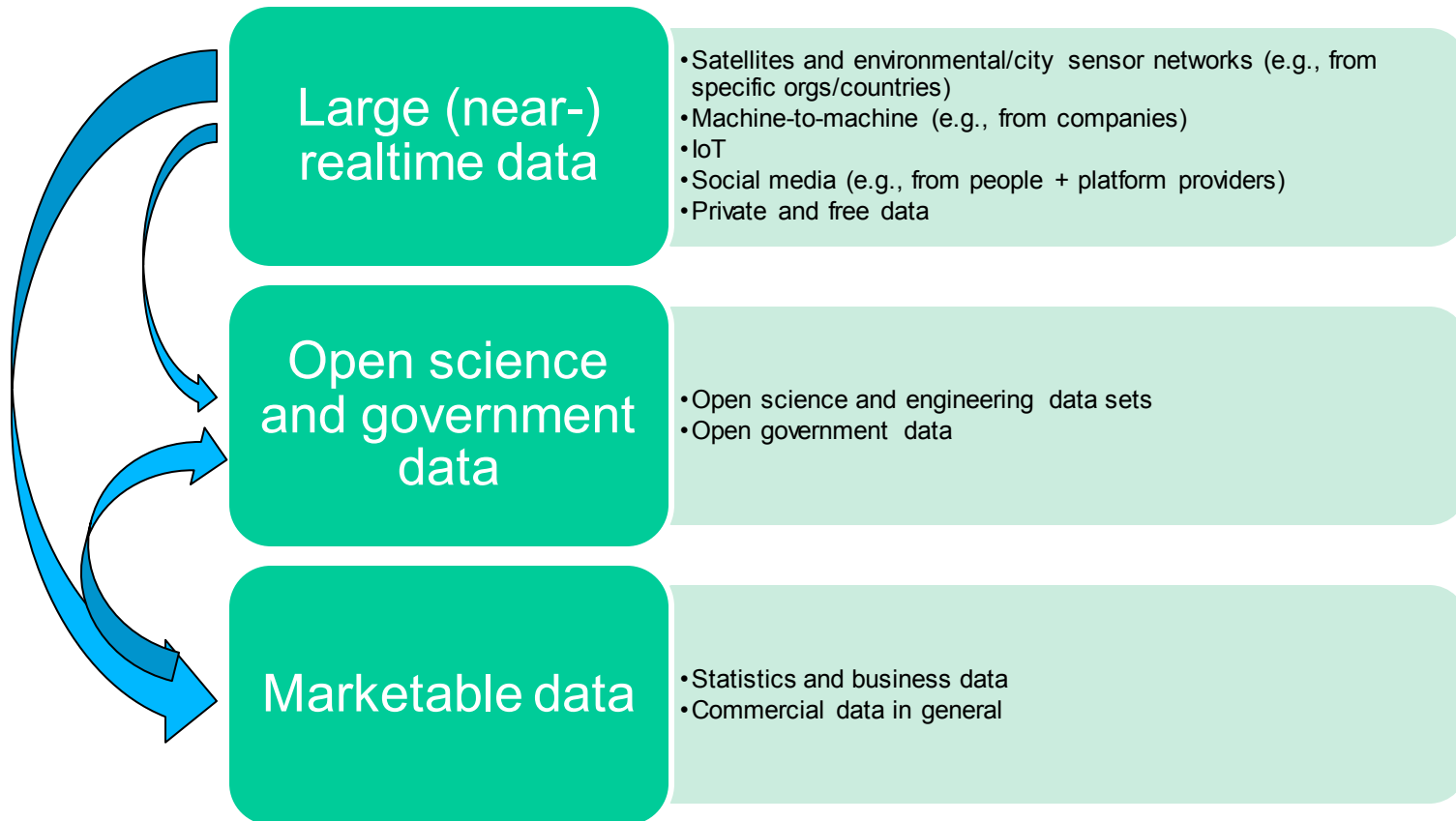
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[http://dsg.tuwien.ac.at/staff/truong](http://dsg.tuwien.ac.at/staff/truong@linhsolar)  
[@linhsolar](#)

- Some emerging models – properties and issues
  - IoT resources
  - Data provisioning models
  - Computational infrastructures/frameworks provisioning
  - Human computation provisioning
  - Software-defined \*
- Today's Internet-scale Computing
- Advanced services engineering
  - Single service/platform engineering
  - Internet-scale multi-platform services engineering

# WHICH ARE EMERGING FORMS OF COMPUTING MODELS, SYSTEMS AND APPLICATIONS THAT YOU SEE?

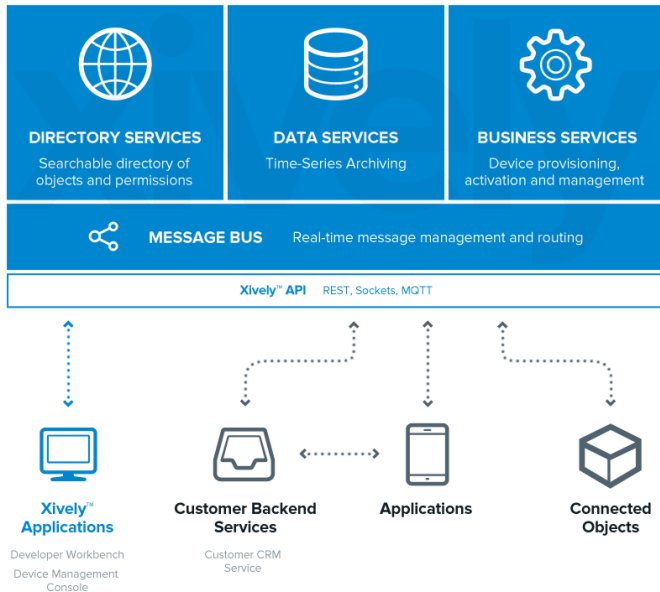
# Some emerging data provisioning models



# Examples of large-scale (near-) realtime data



Xively Cloud Services™  
<https://xively.com/>



ASE Summer 2016

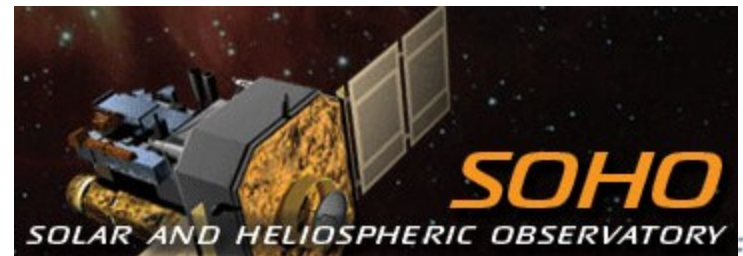
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**CYBERINFRASTRUCTURE**  
*Providing a link between ocean research and discovery*



# Large-scale (near-)realtime data: properties and issues

## Some properties

- Having massive data
- Requiring large-scale, big (near-) real time processing and storing capabilities
- Enabling predictive and realtime data analytics

## Some issues

- Timely analytics
  - Performance and scalability
- Quality of data control
- Handle of unknown data patterns
- Benefit/cost versus quality tradeoffs

# Example of open data

datacatalogs.org

Browse Groups About



a comprehensive list of open data catalogs curated by experts from around the world.

268 registered data catalogs available.

**DATA.GOV.UK** Beta  
Opening up Government

Home Data Participate Apps Location Linked Data Library Lab About

Search | Map Search | Publishers | Tags | Public Roles & Salaries | Spend Browser | Spend Reports

**Search Datasets**  
8729 Datasets

**Tags**  
health, care, transparency, children, disclosure

**Publishers**  
Office for National Statistics (847), Department for Communities and Local Government (739), NHS Information Centre for Health and Social Care (514), British Geological Survey (364), Centre for Ecology & Hydrology (326), Department for Environment, Food and Rural Affairs (322), Welsh Government (241), Department of Health (239), Department for Children, Schools and Families (227), Home Office (221)

**UK Location**  
The UK Location Programme has introduced over 1000 location data records into data.gov.uk and tools to support their use.

publicdata.eu beta — Europe's Public Data

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europe's public data

Find datasets

- Finance and Budgeting (436)
- Environment (227)
- Education and Communication (194)
- Population (145)
- Health (63)
- Social Questions (229)
- Transportation (199)
- Agriculture, Fisheries, Forestry (181)
- Economy and Industry (118)

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amazon web services

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AWS Products & Solutions Public Data Sets Developers Support

**Public Data Sets**  
Public Data Sets on AWS provides a centralized repository of public data sets that can be seamlessly integrated into AWS cloud-based applications.

**Featured Public Data Sets**

- 1000 Genomes Project**  
The 1000 Genomes Project, initiated in 2008, is an international public-private consortium that aims to build the most detailed map of human genetic variation available.
- Common Crawl Corpus**  
A corpus of web crawl data composed of 5 billion web pages. This data set is freely available on Amazon S3 and formatted in the ARC (.arc) file format.
- Google Books Ngrams**  
A data set containing Google Books n-gram corporuses. This data set is freely available on Amazon S3 in a Hadoop friendly file format and is licensed under a Creative Commons Attribution 3.0 Unported License.

# Open data: properties and issues

## Some properties

- Having large, multiple data sources but mainly static data
- Having good quality control in many cases
- Usually providing the data as a whole set

## Some issues

- Fine-grained content search
- Balance between processing cost and performance
- Correlation/combinaton with real-time/private data



# Marketable data examples

Windows Azure Marketplace

Region: United States | Support | Sign In

Learn Applications Data My Account Publish

Search the Marketplace

HOME > DATA

category

41 Results in: DATA PAID BUSINESS AND FINANCE

Sort By: Date Added Name Publisher

1 2 3 4 5

**Bustling Manufacturers & Business Services List** data  
published by: DNB  
Bustling Manufacturers & Business Services list is a market segmentation that includes over 30,000 large manufacturers and businesses with an average annual sales volume of \$40 million. The companies in this list also have high trade activity, maintained steady size in last 4 years and have been in business for an average of 20 years.

**Crime Statistics for England & Wales** data  
published by: Custom Web Apps, Ltd  
The crime data is released by the National Policing Improvement Agency (NPIA) at the end of every month and contains all recorded crime and anti-social behaviour for England & Wales. Data is available from Dec 2010 to present to a level of full UK postcode as well as postcode sector, postcode district, and postcode area.

## Full DataSet Listing

Following is a list of all available AggData. If you can't find what you're looking for, you may [contact us](#) for a custom solution.

Title	Record Count	Regions	Last Updated	Price	Add to Cart
Complete List of 1 800 Flowers	87		11/18/2011	\$19.00	<a href="#">Add To Cart</a>
Complete List of 24 Hour Fitness Locations	415		08/13/2012	\$29.00	<a href="#">Add To Cart</a>
Complete List of 2nd Wind Exercise Locations	47		05/25/2012	\$19.00	<a href="#">Add To Cart</a>
Complete List of 6th Avenue Locations	7		01/23/2012	\$19.00	<a href="#">Add To Cart</a>
Complete List of 7-11 Canada Locations	480		07/02/2012	\$29.00	<a href="#">Add To Cart</a>
Complete List of 7-11 Locations	7,150		08/20/2012	\$59.00	<a href="#">Add To Cart</a>
Complete List of 99 Cents Only Stores	298		05/07/2012	\$29.00	<a href="#">Add To Cart</a>
Complete List of A Affordable Locations	46		10/15/2012	\$19.00	<a href="#">Add To Cart</a>
Complete List of A&P Supermarket Locations	106		08/30/2012	\$29.00	<a href="#">Add To Cart</a>

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[in Share](#) [+1](#)

# Marketable data: properties and issues

## Some properties

- Can be large, multiple data sources but mainly static data
- Having good quality control
- Have strong data contract terms
- Some do not offer the whole dataset

## Some issues

- Multiple levels of service/data contracts
- Compatible with other data sources w.r.t. contract
- Cost w.r.t. up-to-date data
- Near-realtime data marketplaces

# Emerging computing infrastructure and platform provisioning models

- Infrastructure-as-a-Service
  - Machine as a service
  - Storage as a Service
  - Database as a Service
  - Network as a Service (think about Network Function Virtualization with 5G)
- Platform-as-a-Service
  - Application middleware
  - Computational frameworks
  - Data processing frameworks
  - Management middleware (e.g., monitoring, control, deployment)

# Examples



# Emerging computing infrastructure/platform provisioning models– properties and issues

## Some properties

- Rich types of services from multiple providers
  - Better choices in terms of functions and costs
- Concepts are similar but diverse APIs
- Strong dependencies/tight ecosystems

## Some issues

- On-demand information management from multiple sources
- APIs complexity and API management
- Cross-vendor integration
- Execution in Multi-cloud environments
- Data locality

# Emerging human computation models

- Crowdsourcing platforms
  - (Anonymous) people computing capabilities exploited via task bids
- Expert as Individual Compute Unit
  - An individual is treated like „a processor“ or “functional unit“. A service can wrap human capabilities to support the communication and coordination of tasks
- A set of individuals as Social Compute Unit
  - A set of people and software that are initiated and provisioned as a service for solving tasks

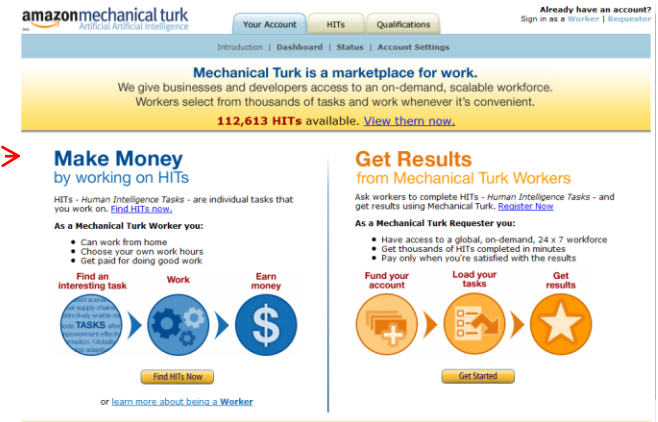
The main point: humans are a computing element

# Examples of human computation (2)

```

1  import edu.umass.cs.automan.adapters.MTurk._
2
3  object SimpleProgram extends App {
4      val a = MTurkAdapter { mt =>
5          mt.access_key_id = "XXXX"
6          mt.secret_access_key = "XXXX"
7      }
8
9      def which_one() = a.RadioButtonQuestion { q =>
10         q.budget = 8.00
11         q.text = "Which one of these does not belong?"
12         q.options = List(
13             a.Option('oscar, "Oscar the Grouch"),
14             a.Option('kermit, "Kermit the Frog"),
15             a.Option('spongebob, "Spongebob Squarepants"),
16             a.Option('cookie, "Cookie Monster"),
17             a.Option('count, "The Count")
18         )
19     }
20
21     println("The answer is " + which_one())
22 }

```



The screenshot shows the Amazon Mechanical Turk dashboard. At the top, there are navigation tabs for 'Your Account', 'HITS', and 'Qualifications'. Below this, a banner states 'Mechanical Turk is a marketplace for work.' and '112,613 HITS available.' The main content area is divided into two columns. The left column is titled 'Make Money by working on HITS' and lists benefits for workers such as 'Can work from home' and 'Choose your own work hours'. The right column is titled 'Get Results from Mechanical Turk Workers' and lists benefits for requesters such as 'Have access to a global, on-demand, 24 x 7 workforce' and 'Get thousands of HITS completed in minutes'. Both columns include flowcharts and 'Find HITS Now' or 'Get Started' buttons.

Source: Daniel W. Barowy, Charlie Curtsinger, Emery D. Berger, Andrew McGregor: **AutoMan: a platform for integrating human-based and digital computation.** OOPSLA 2012: 639-654

# Human computation models – properties and issues

## Some properties

- Huge number of people
- Capabilities might not know in advance
- Unpredictable behavior
- Simple coordination models

## Some issues

- Reliability
- Quality control
- Reliability assurance
- Proactive, on-demand acquisition
- Incentive strategies
- Collectives



# Emerging Software-defined \*

- Software-defined concepts
  - To have better way to manage dynamic changes in computation, network and data
  - Capabilities to manage and control computation, data, and network features at runtime using software
  - Management and control are performed via open APIs
- Software-defined techniques
  - Software-defined networking, Software-defined storage, Software-defined services

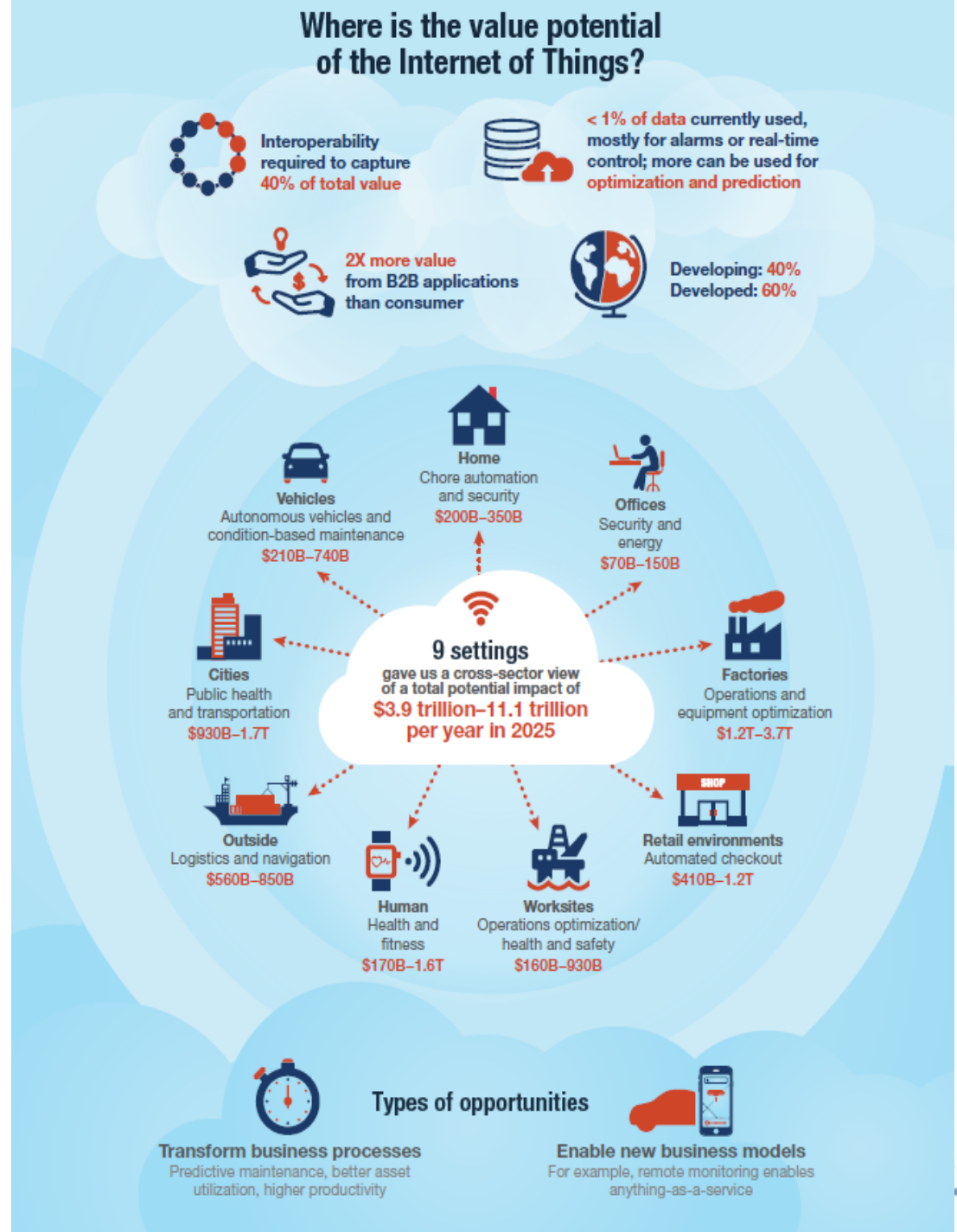
- KIRKPATRICK , K. Software-defined networking. Commun. ACM 56, 9 (Sept. 2013), 16–19.
- LANGO , J. Toward software-defined slas. Commun. ACM 57, 1 (Jan. 2014), 54–60.
- SUGIKI , A., AND KATO , K. Elements and composition of software-defined data centers. In Proceedings of the Posters and Demo Track (New York, NY, USA, 2012), Middleware '12, ACM, pp. 3:1–3:2.

# Emerging Software-defined \*

Discussion time:

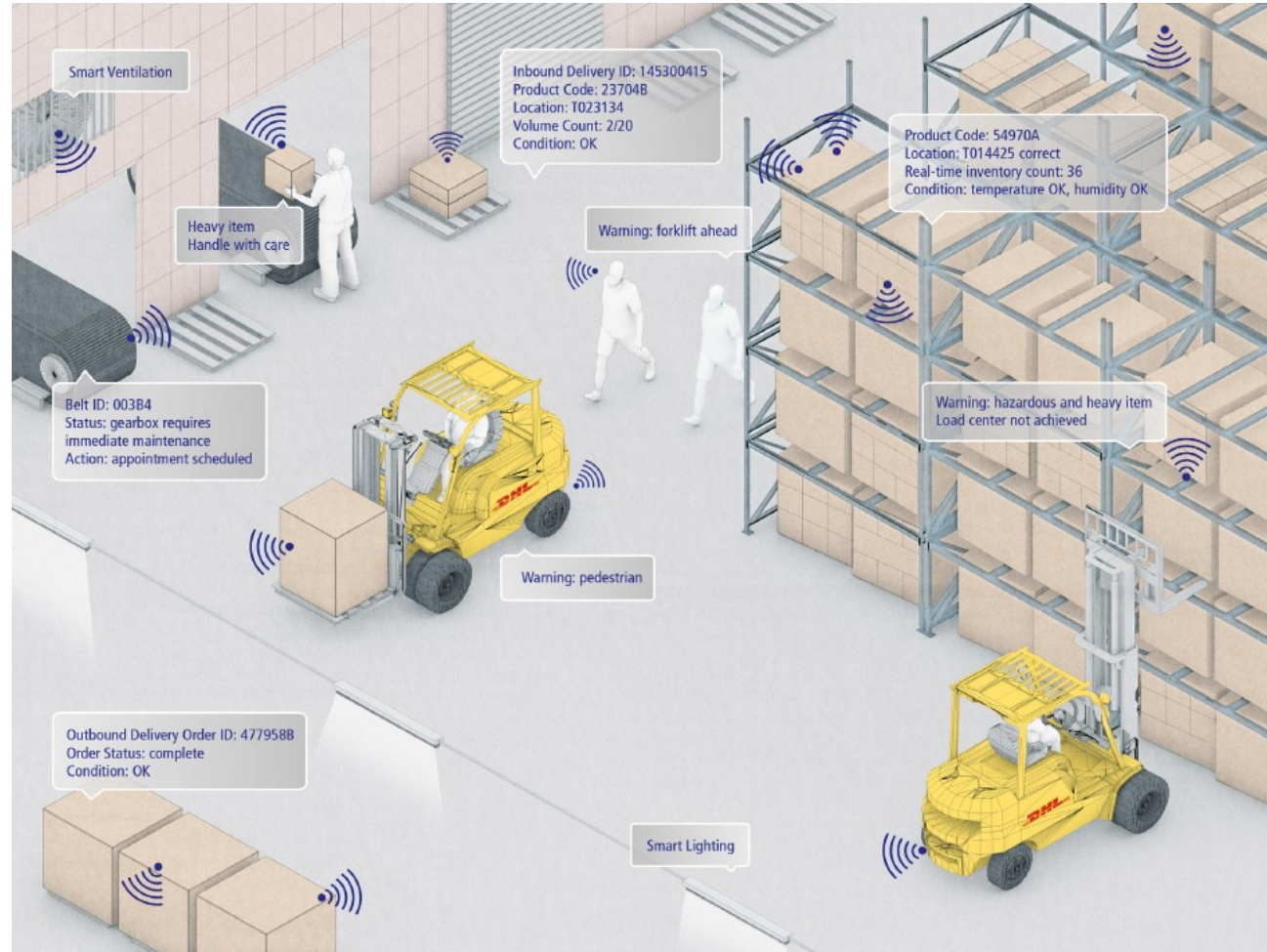
**WHERE WE CAN FIND SOME  
OPPORTUNITIES?  
DO I NEED TO TAKE THEM?  
WHY?**

Figure source: McKinsey  
 Global Institute: THE  
 INTERNET OF THINGS:  
 MAPPING THE VALUE  
 BEYOND THE HYPE  
 JUNE 2015  
 HIGHLIGHTS



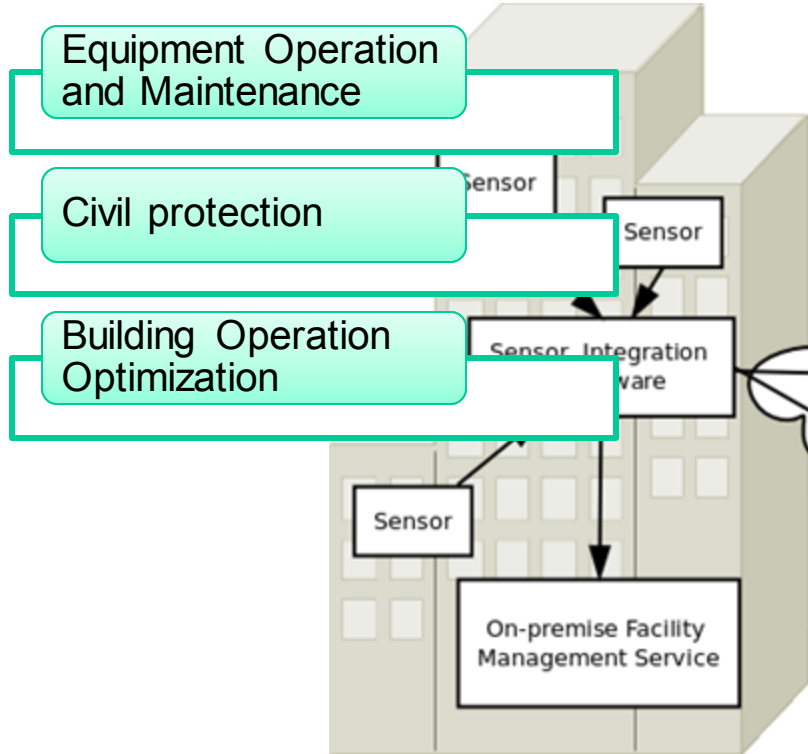
# Logistics scenario from DHL

Figure source: DHL  
Trend Research &  
Cisco Consulting  
Services, **INTERNET  
OF THINGS**  
IN LOGISTICS, 2015

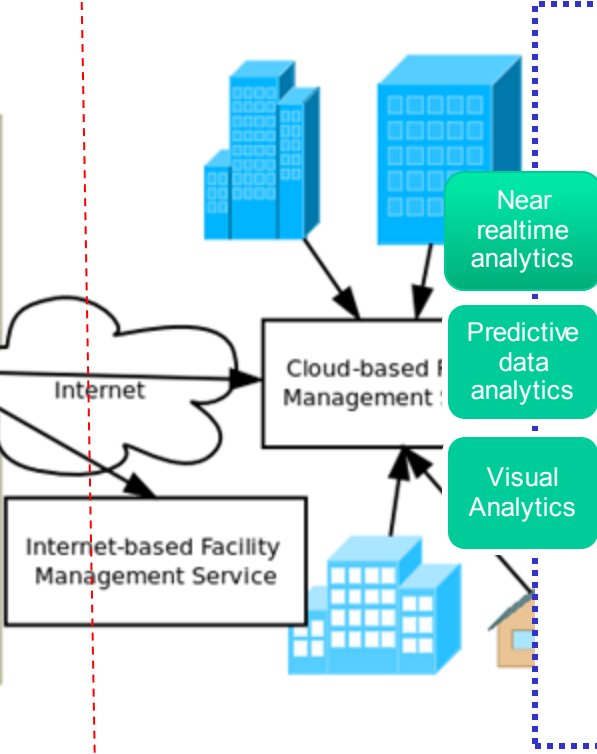


# Smart building management

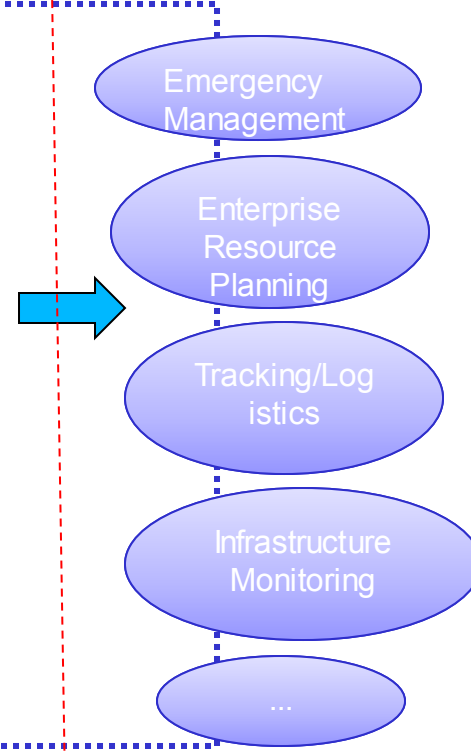
Infrastructure/Internet of Things



Internet/public cloud boundary



Organization-specific boundary



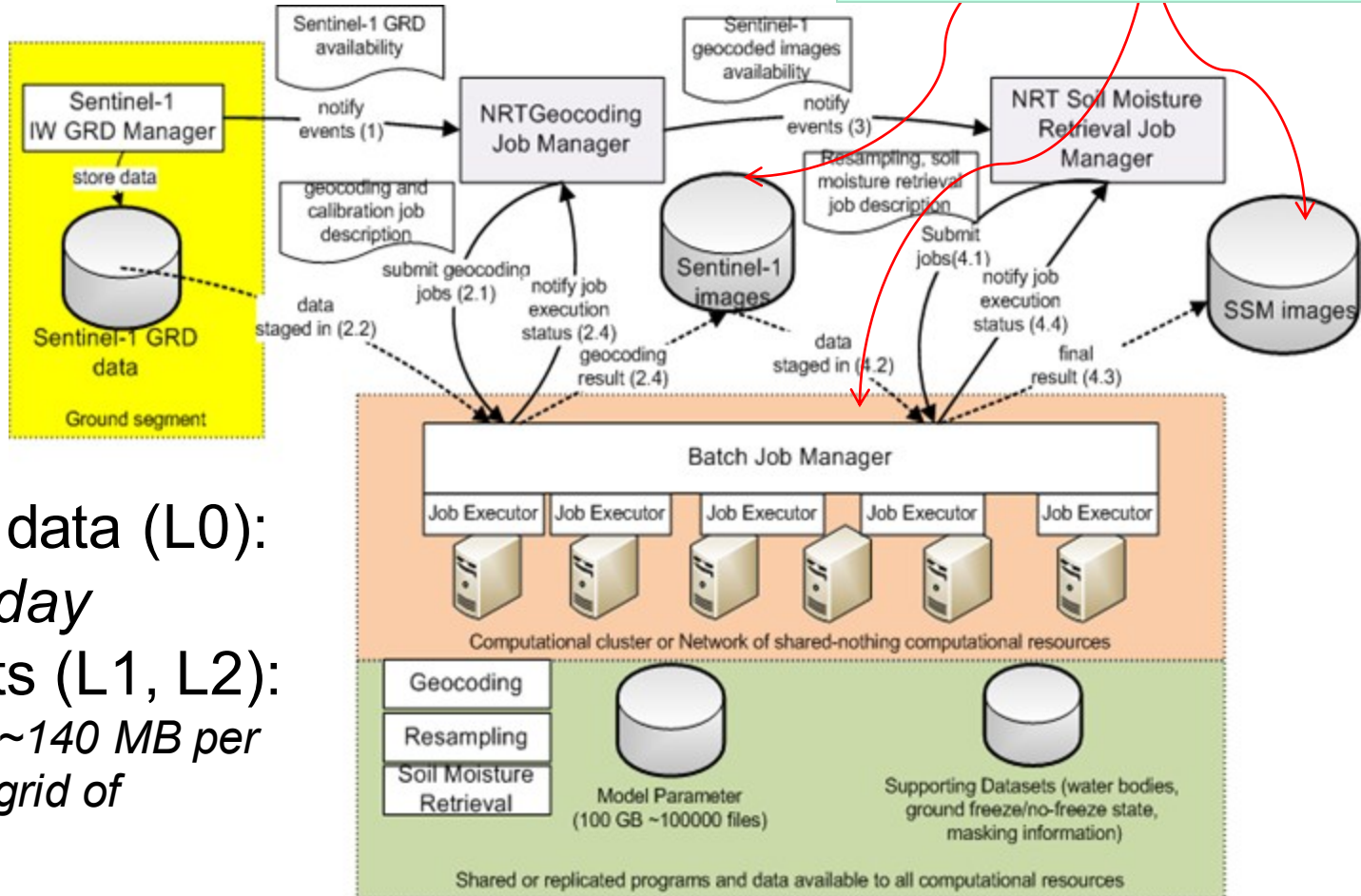
Cities, e.g. including:  
10000+ buildings  
1000000+ sensors

Can we combine open government data with building monitoring data?



Can we combine them with open government data?

## Soil moisture analysis for Sentinel-1



A lot of input data (L0):  
~2.7 TB per day

A lot of results (L1, L2):  
e.g., L1 has ~140 MB per day for a grid of 1kmx1km

Michael Hornacek, Wolfgang Wagner, Daniel Sabel, Hong-Linh Truong, Paul Snoeij, Thomas Hahmann, Erhard Diedrich, Marcela Doubkova, **Potential for High Resolution Systematic Global Surface Soil Moisture Retrieval Via Change Detection Using Sentinel-1**, IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, April, 2012

# Open data and social data

Source: <http://www.undata-api.org/>

Source:

<http://www.strikeiron.com/Catalog/StrikeIronServices.aspx>

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<dataset organisation="WHO" category="Demographic and socioeconomic statistics" name="Population total"/>
<dataset organisation="WHO" category="Demographic and socioeconomic statistics" name="Population under 15 (percent)"/>
<dataset organisation="WHO" category="Demographic and socioeconomic statistics" name="Sex ratio at birth (per 1,000 male)"/>
<dataset organisation="WHO" category="Demographic and socioeconomic statistics" name="Total fertility rate (percent)"/>
<dataset organisation="WHO" category="Demographic and socioeconomic statistics" name="Total population below the poverty line (percent living on less than US$1 a day)"/>
<dataset organisation="WHO" category="Demographic and socioeconomic statistics" name="Total population under 60 (percent)"/>
<dataset organisation="WHO" category="Demographic and socioeconomic statistics" name="Total population under 15 (percent)"/>
<dataset organisation="WHO" category="Demographic and socioeconomic statistics" name="Total population under 5 (percent)"/>
<dataset organisation="WHO" category="Demographic and socioeconomic statistics" name="Total population under 4 (percent)"/>
<dataset organisation="WHO" category="Demographic and socioeconomic statistics" name="Total population under 3 (percent)"/>
<dataset organisation="WHO" category="Demographic and socioeconomic statistics" name="Total population under 2 (percent)"/>
<dataset organisation="WHO" category="Demographic and socioeconomic statistics" name="Total population under 1 (percent)"/>
<dataset organisation="WHO" category="Demographic and socioeconomic statistics" name="Total population under 0 (percent)"/>
```

DATA.GOV

INTERNATIONAL OPEN GOVERNMENT DATA CONFERENCE

Sponsored by: U.S. General Services Administration

Hosted by: U.S. Department of Commerce

November 11 - 17, 2010 Washington, DC

Most Popular Datasets

- U.S. Overseas Loans and Grants (Greenbook)
- Worldwide M+ Earthquake, Feb 7 Days
- Fed and Drug Administration-Recalls
- FDC Failed Bank List
- Clean Air Markets Clear Air Interstate Rule

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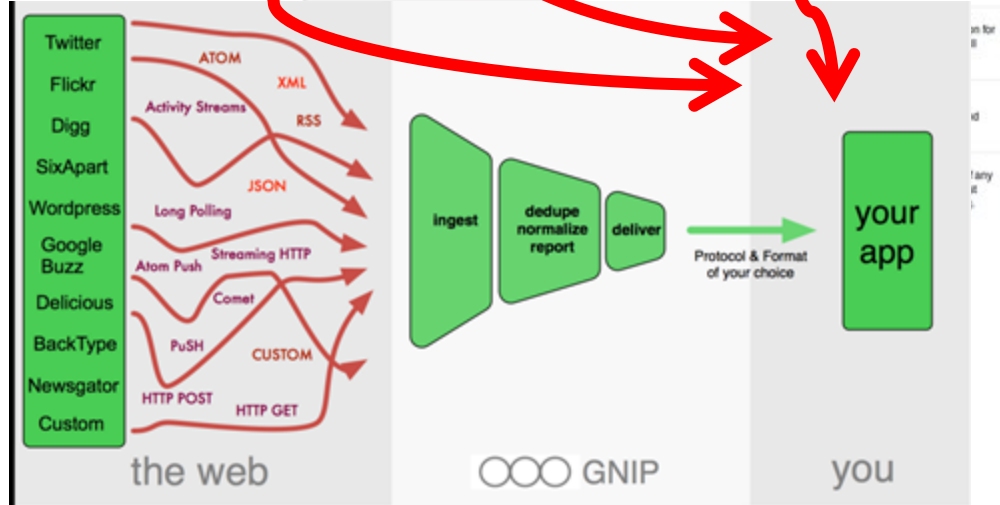
Search our catalogs. SEARCH

APPS COMMUNITY SEMANTIC WEB

With so much government data to work with, developers are creating a wide variety of applications, mashups, and visualizations. From crime statistics by neighborhood to the best towns to find a job to seeing the environmental health of your community—these applications arm citizens with the information they need to make decisions every day. Enjoy these highlights of the hundreds of applications available.

7 Other nations establishing open data  
18 States now offering data sites  
9 Cities in America with open data  
236 New applications from Data.gov datasets  
253 Data contacts in Federal Agencies  
305,709 Datasets available on Data.gov

<b>ZIP and Postal Code Information</b> <a href="#">Try It Now</a>	Turns out you can learn a lot from a US Zip or Canadian Postal Code. This service instantly retrieves the city, state, county, time zone, latitude and longitude, ZIP and Postal Codes within a radius, along with US census information for a given ZIP or Postal Code.
<b>Cortera Business Vitals</b> <a href="#">Try It Now</a>	Think valuable insights about companies are tough to come by? Think again. Cortera Business Vitals delivers the key elements of a business location including a unique ID, complete address, phone number, URL, SIC, NAIC, employees, sales and year started.
<b>Zacks Company</b> <a href="#">Try It Now</a>	Provides live financial information on public companies from Zacks, including descriptions, pricing information, market caps, peer information, EPS, dividend information and other key financial ratios.
<b>Zacks Consensus</b> <a href="#">Try It Now</a>	Provides live financial information on public companies from Zacks, including current consensus on EPS estimates, estimates added, removed, changed, or revised, EPS perspectives on 30-day, quarter, 6-month, this year, and coming year, long term growth consensus, and more.
<b>Zacks Summary</b> <a href="#">Try It Now</a>	Provides live financial information on public companies from Zacks, including broker buy/sell recommendations, earnings estimates, consensus EPS trends, EPS surprises both current and historical, and earnings comparisons to the industry.
<b>NCOA Verification</b>	Did you know 40 million Americans change their address annually? Need help keeping your data clean and deliverable? StrikeIron can help. NCOA Verification can not only identify who has moved, but will provide the new address.



Source: <http://docs.gnip.com/w/page/23722723/Introduction-to-Gnip>



# Video analytics + business applications/public security

## Use Case 3: Video Analytics

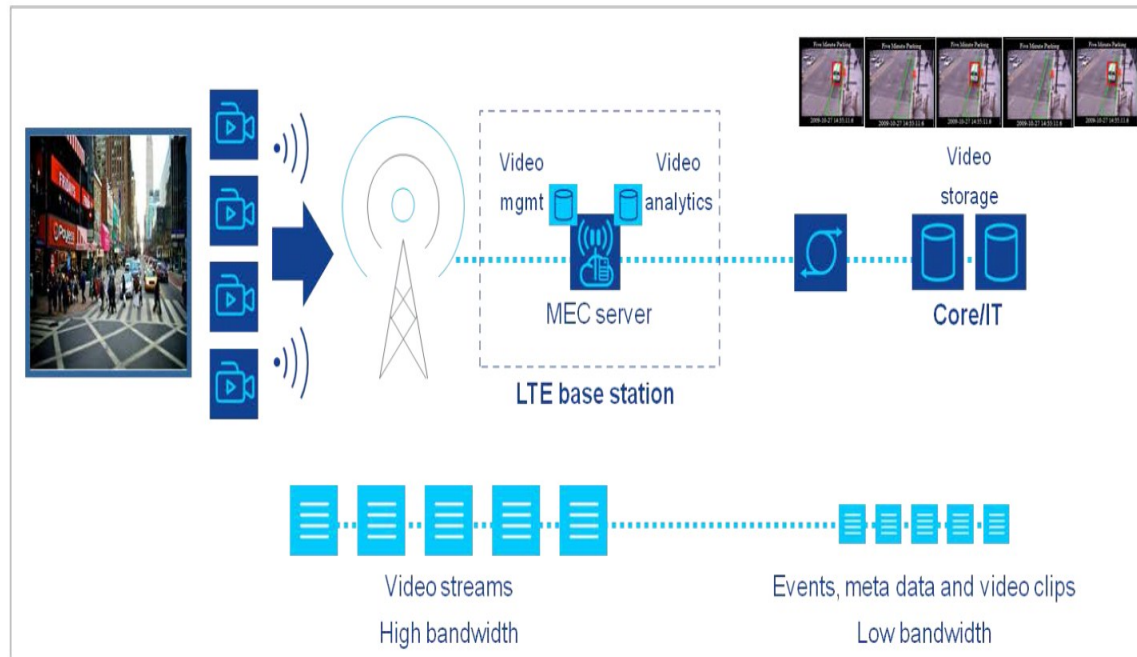


Figure 4: Example of video analytics

Figure source:

[https://portal.etsi.org/portals/0/tbpages/mec/docs/mobile-edge\\_computing\\_-\\_introductory\\_technical\\_white\\_paper\\_v1%2018-09-14.pdf](https://portal.etsi.org/portals/0/tbpages/mec/docs/mobile-edge_computing_-_introductory_technical_white_paper_v1%2018-09-14.pdf)

# Critical infrastructures/services for citizens and business

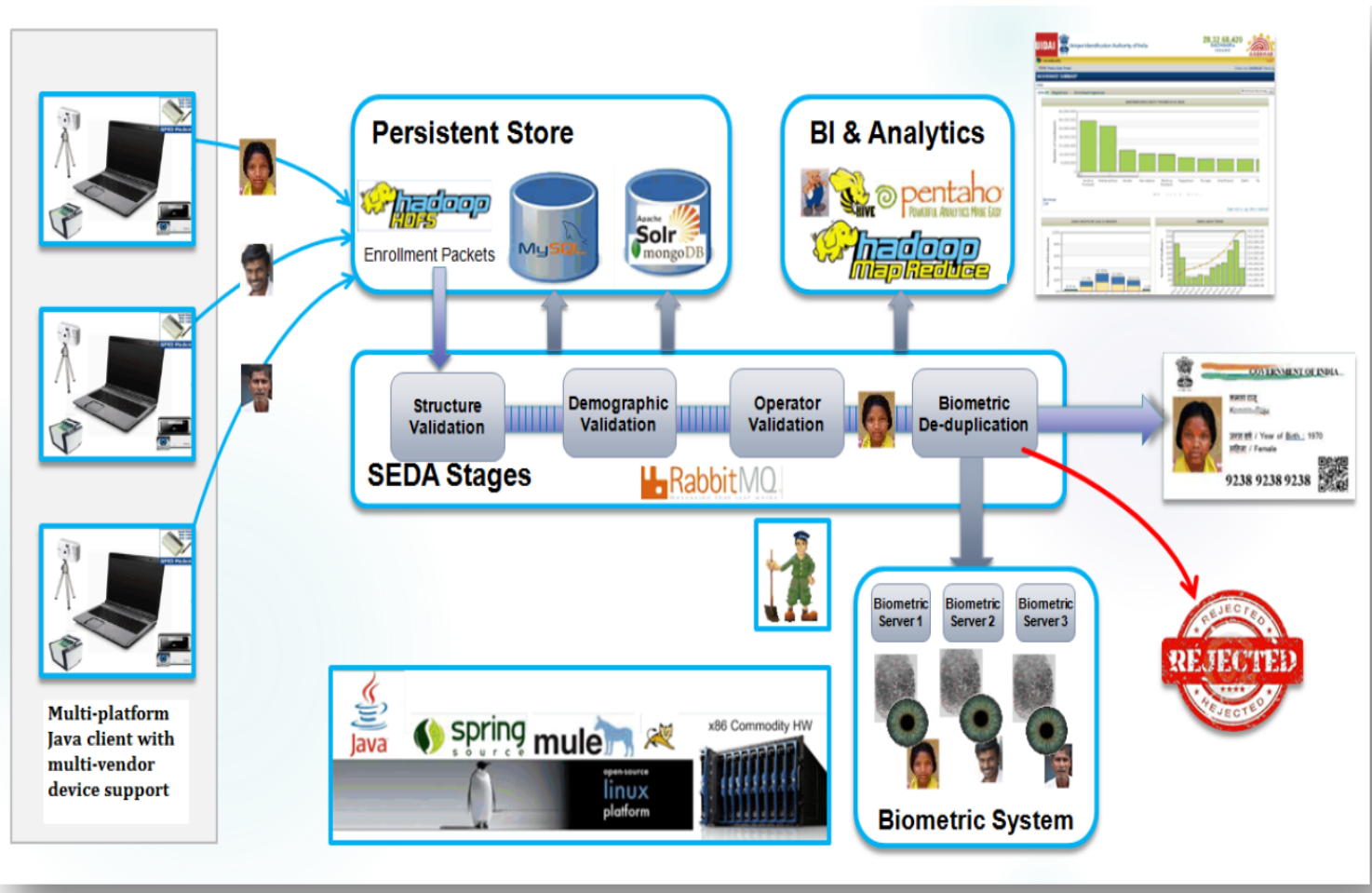
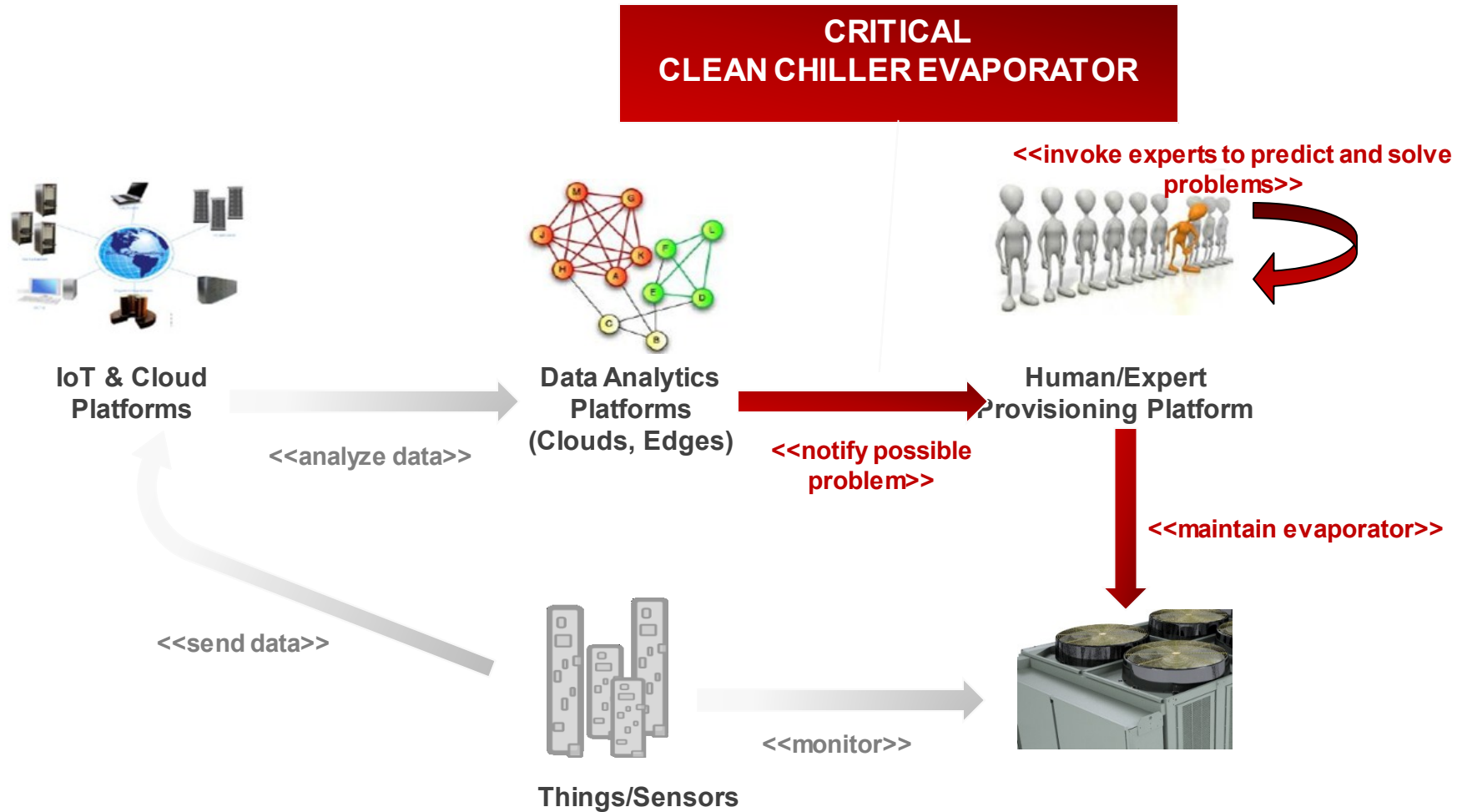


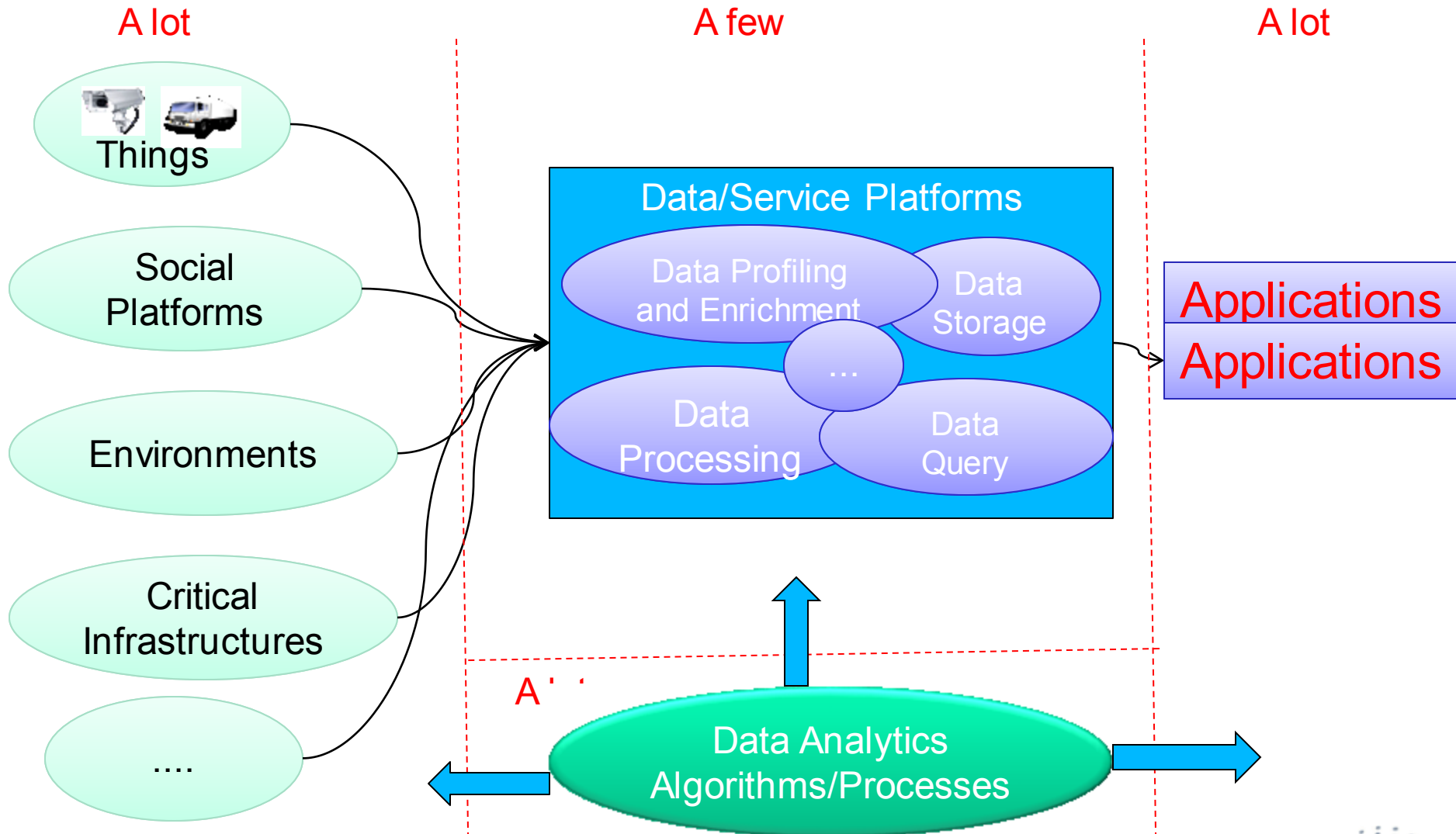
Figure source: [http://uidai.gov.in/images/AadhaarTechnologyArchitecture\\_March2014.pdf](http://uidai.gov.in/images/AadhaarTechnologyArchitecture_March2014.pdf)

# CONVERGENCE OF MULTIPLE COMPUTING MODELS

# Predictive Maintenance



# Cloud-based Analytics

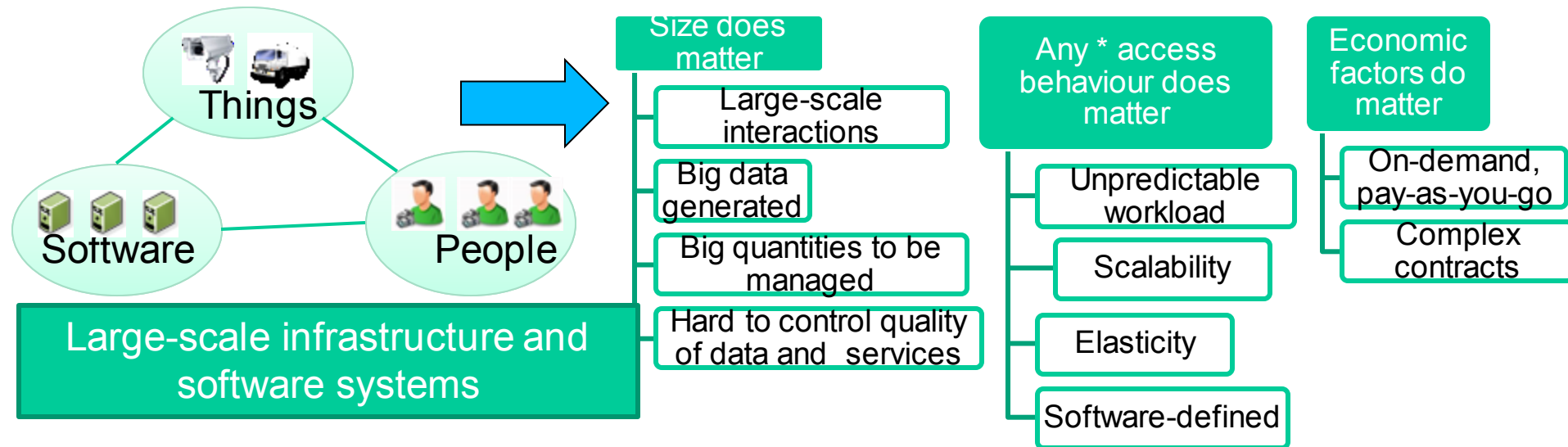


# BRING YOUR OWN EXPERIENCE: CLOUD-BASED ANALYTICS

See also <http://www.allthingsdistributed.com/2015/03/the-importance-of-cloud-based-analytics.html>

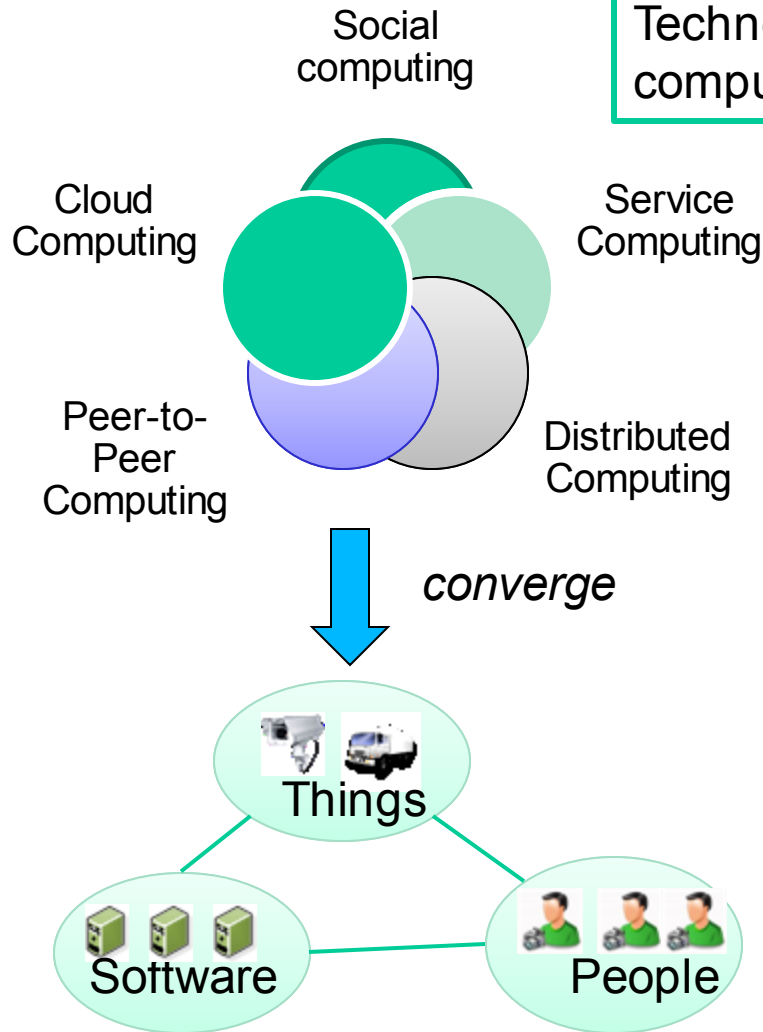
# Today's Computing Models

- Internet infrastructure and software connect *contents, things, and people*, each has different roles (*computation, sensing, analytics, etc.*)



# Today's Computing Models

Technologies and computing models

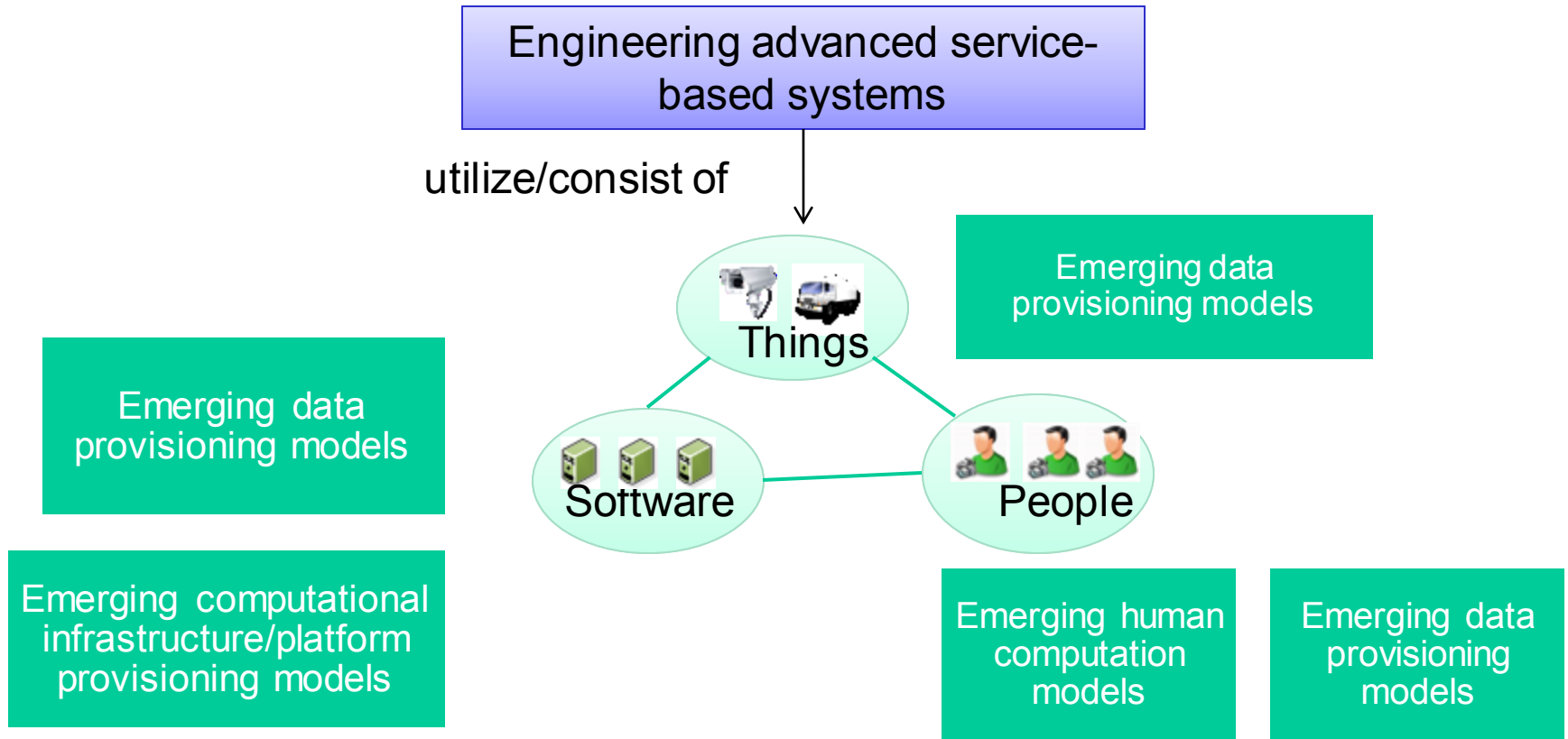


- Big and high performance centralized data analytics
- IoT data streaming analytics
- Large-scale applications spanning data centers and edge servers/gateways
- Adaptive collective systems of humans and machines

Emerging forms of computing models, systems and applications



# Summary of emerging models wrt advanced service-based systems



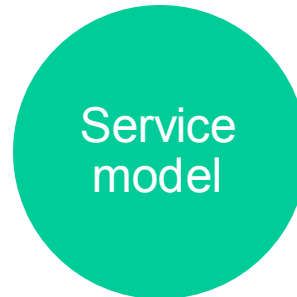
Challenges in Virtualization, Programming, Communication, and Coordination, etc.

# ADVANCED SERVICES ENGINEERING'S FOCUS

# Single service/platform engineering – service unit (1)

- The service model and the unit concept can be applied to things, people and software

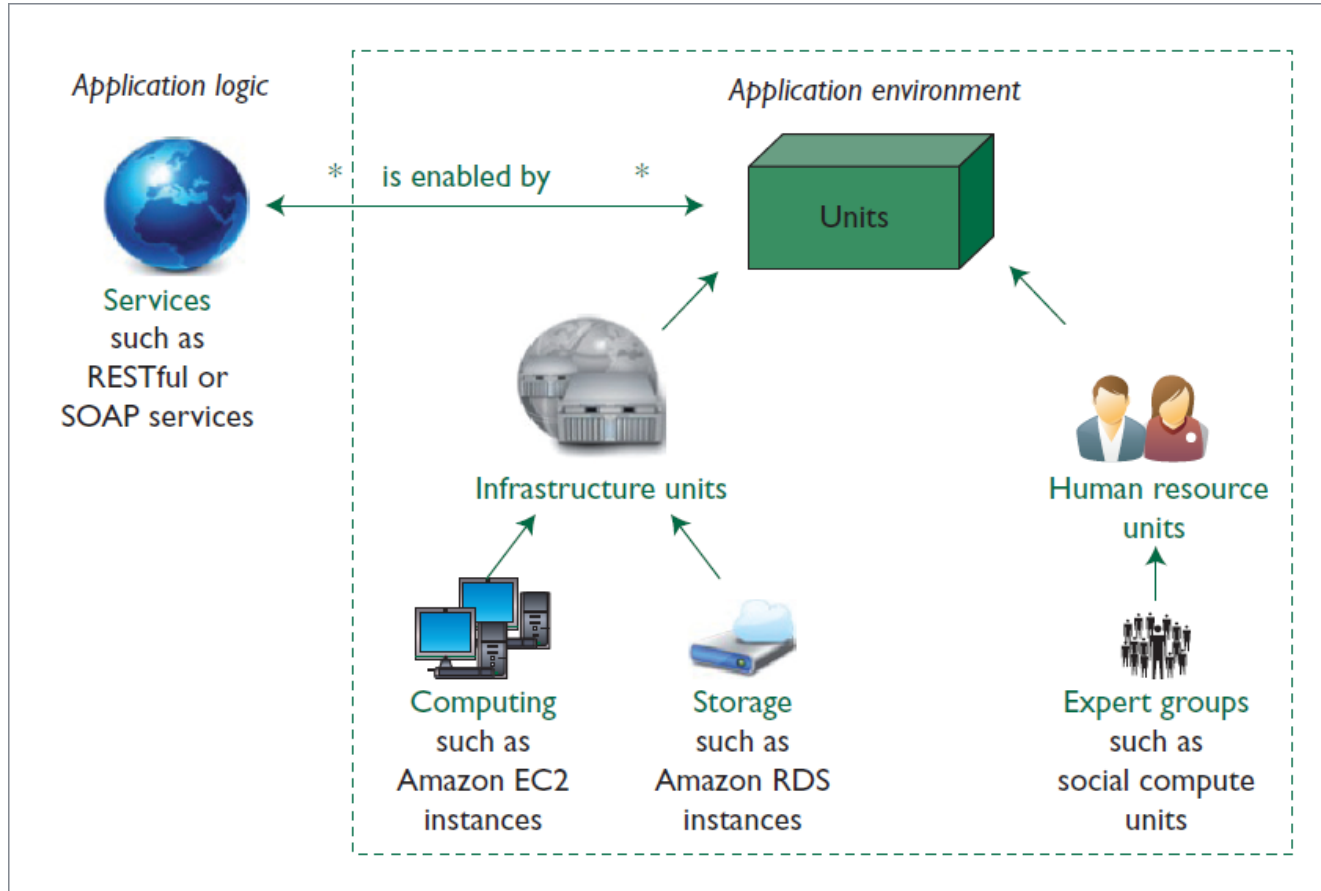
Consumption,  
ownership,  
provisioning, price, etc.



„basic  
component“/“basic  
function“ modeling  
and description



# Single service/platform engineering – service units (2)



Source: Stefan Tai, Philipp Leitner, Schahram Dustdar: Design by Units: Abstractions for Human and Compute Resources for Elastic Systems. IEEE Internet Computing 16(4): 84-88 (2012)

# Single service/platform engineering – service unit provisioning

- Provisioning software under services
- Provisioning things under services
- Provisioning human under services
  - Crowd platforms of massive numbers of individuals
  - Individual Compute Unit (ICU)
  - Social Compute Unit (SCU)

1. Mark Turner, David Budgen, and Pearl Brereton. 2003. **Turning Software into a Service**. *Computer* 36, 10 (October 2003), 38-44. DOI=10.1109/MC.2003.1236470 <http://dx.doi.org/10.1109/MC.2003.1236470>
2. Luigi Atzori, Antonio Iera, and Giacomo Morabito. 2010. **The Internet of Things: A survey**. *Comput. Netw.* 54, 15 (October 2010), 2787-2805. DOI=10.1016/j.comnet.2010.05.010 <http://dx.doi.org/10.1016/j.comnet.2010.05.010>
3. Dominique Guinard, Vlad Trifa, Stamatis Karnouskos, Patrik Spiess, Domnic Savio: **Interacting with the SOA-Based Internet of Things: Discovery, Query, Selection, and On-Demand Provisioning of Web Services**. *IEEE T. Services Computing* 3(3): 223-235 (2010)
4. Schahram Dustdar, Kamal Bhattacharya: **The Social Compute Unit**. *IEEE Internet Computing* 15(3): 64-69 (2011)
5. Hong-Linh Truong, Schahram Dustdar, Kamal Bhattacharya **"Programming Hybrid Services in the Cloud"**, Springer-Verlag, 10th International Conference on Service-oriented Computing (ICSOC 2012), November 12-16, 2012, Shanghai, China

# Single service/platform engineering – examples (1)

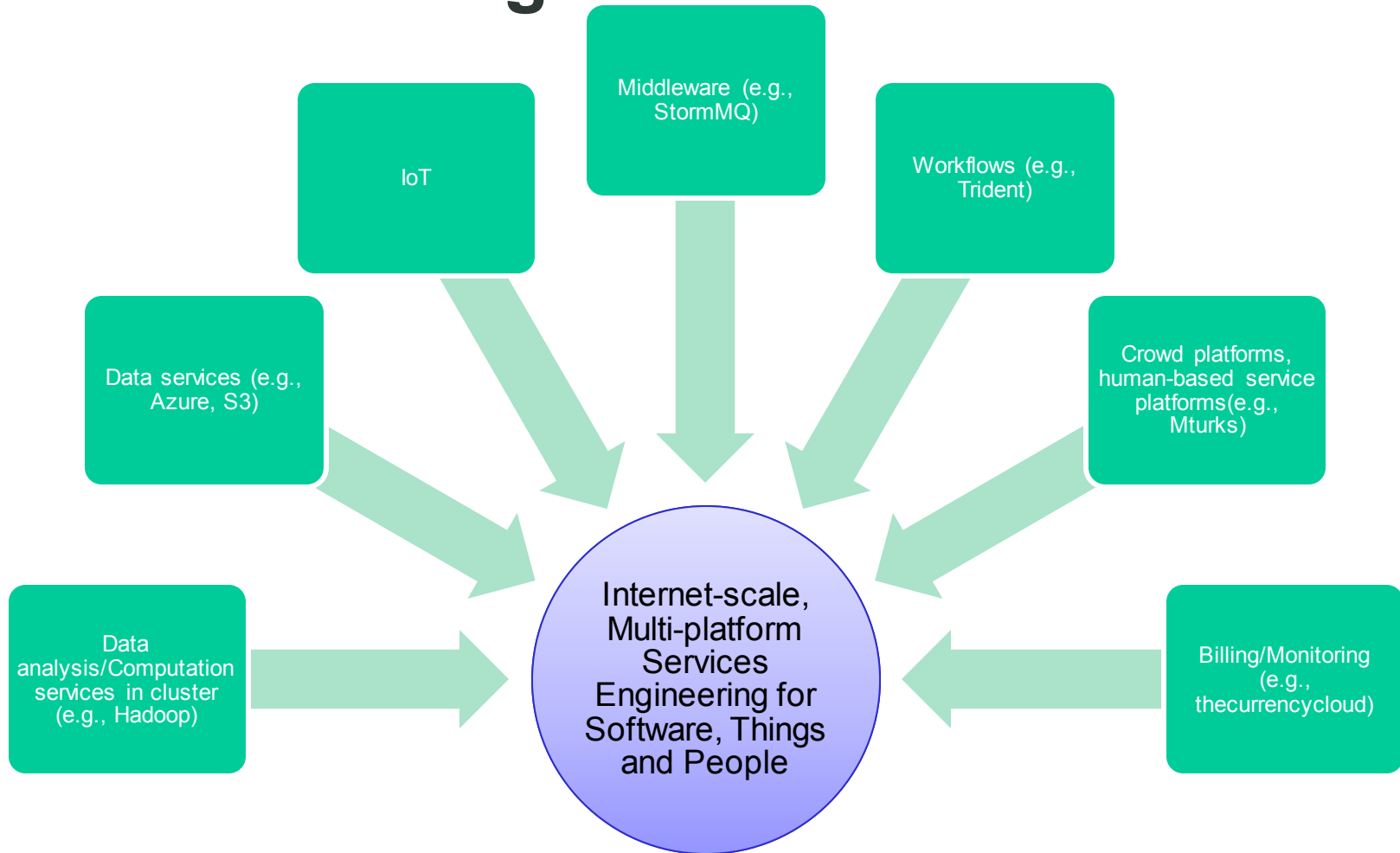
- Service engineering with a single system/platform
  - Using Excel to access Azure datamarket places
  - Using Boto to access data in Amazon S3
  - Using Hadoop within a cluster to process local data
  - Using workflows to process data (e.g., Trident/Taverna/ASKALON)
  - Using StormMQ to store messages

# Single service/platform engineering – examples (2)

The screenshot shows a Microsoft Excel spreadsheet with a table of flight data. The table has columns for ArrDelay, Carrier, DayofMo, DepDelay, Dest, FlightDat, Month, Origin, RowId, and Year. The data includes flight information for various carriers like US, PHX, DCA, KOA, BUR, LIH, DCA, LAS, MSP, SEA, ONT, CLT, BOS, DEN, and SEA.

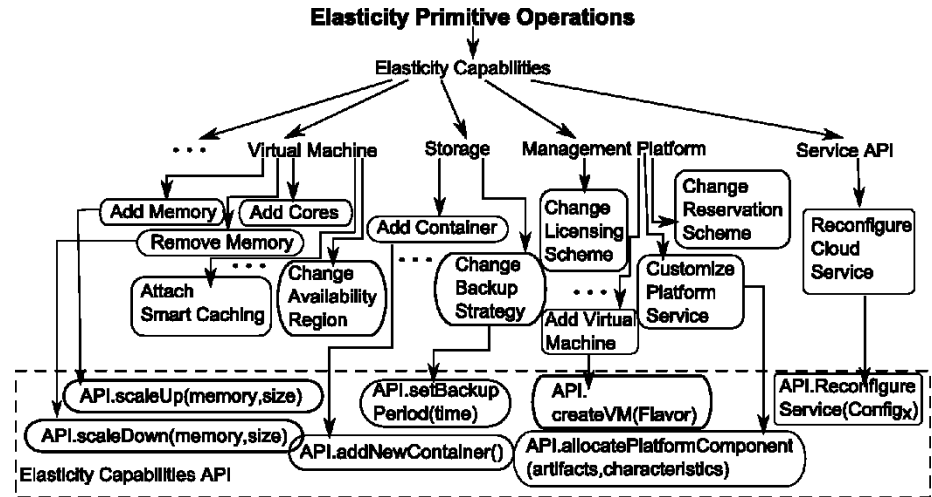
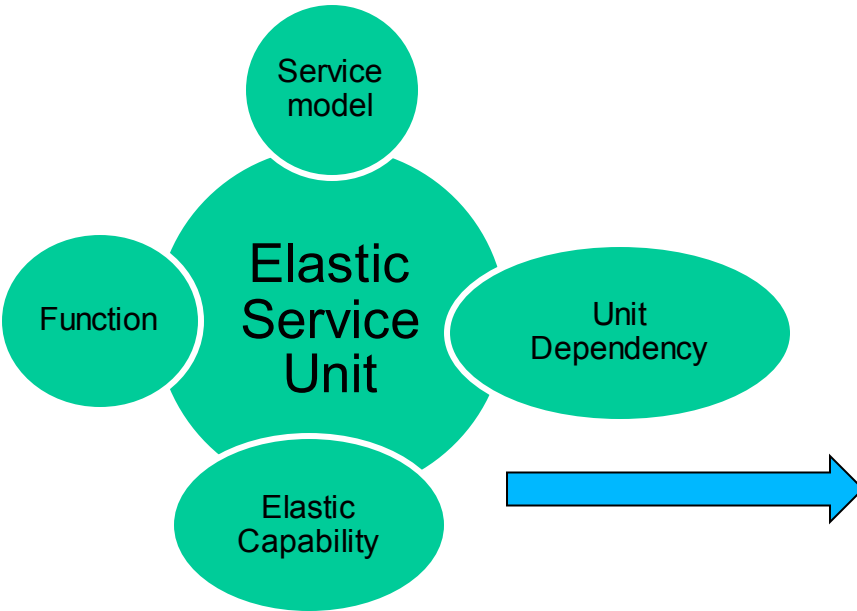
Overlaid on the Excel window is a Firefox browser window showing the Windows Azure Marketplace search results for 'US Air Carrier Flight Delays'. The search results show 749 results, sorted by 'Datum hinzugefügt'. The top result is 'US Air Carrier Flight Delays' published by OakLeaf Systems, with a description: 'Departure and arrival delays in minutes for domestic flights certified air carriers by month from 1987. Other fields are code, and origin and destination airport ICAO codes'.

# Internet-scale multi-platform services engineering – required technologies





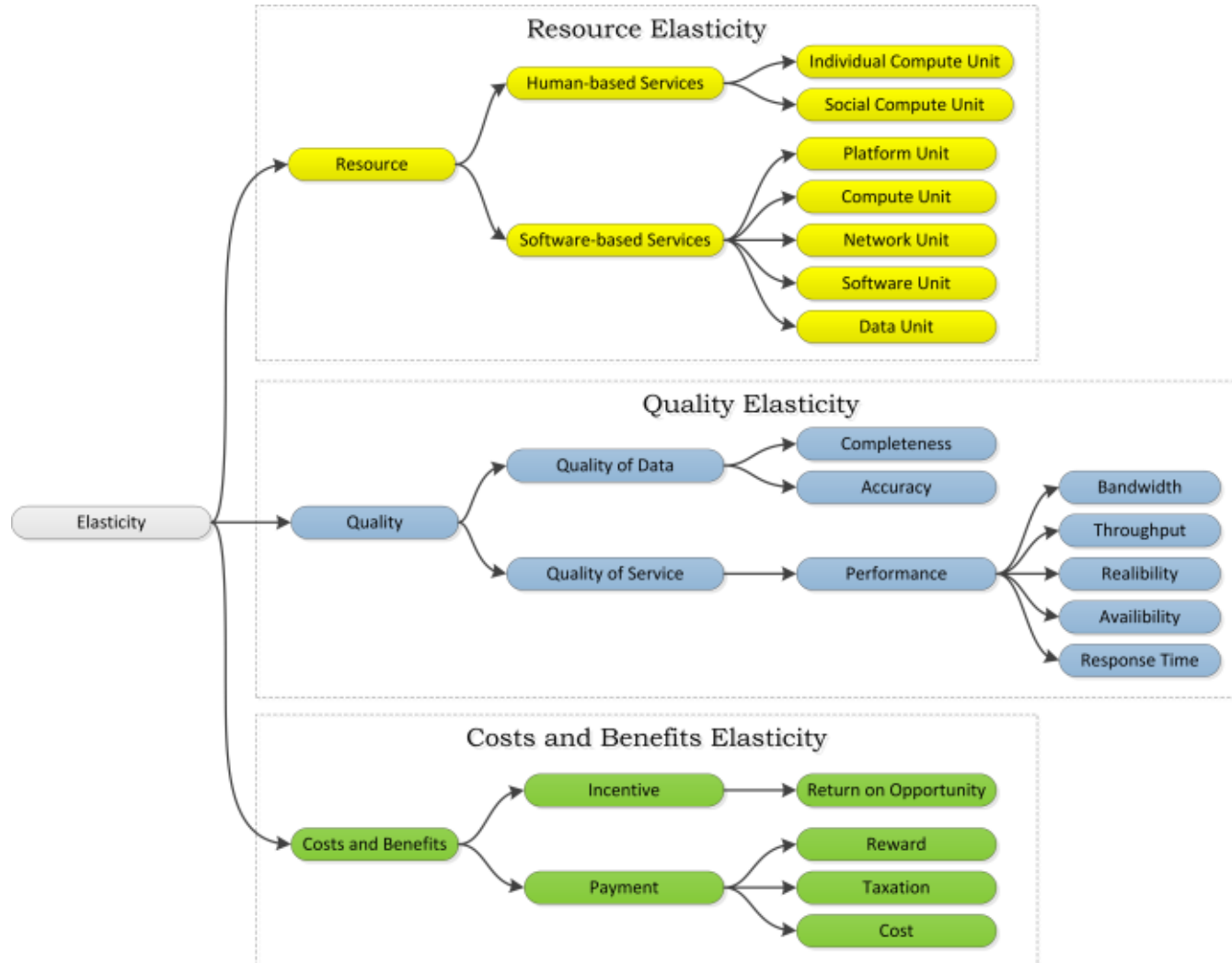
# From service unit to elastic service unit



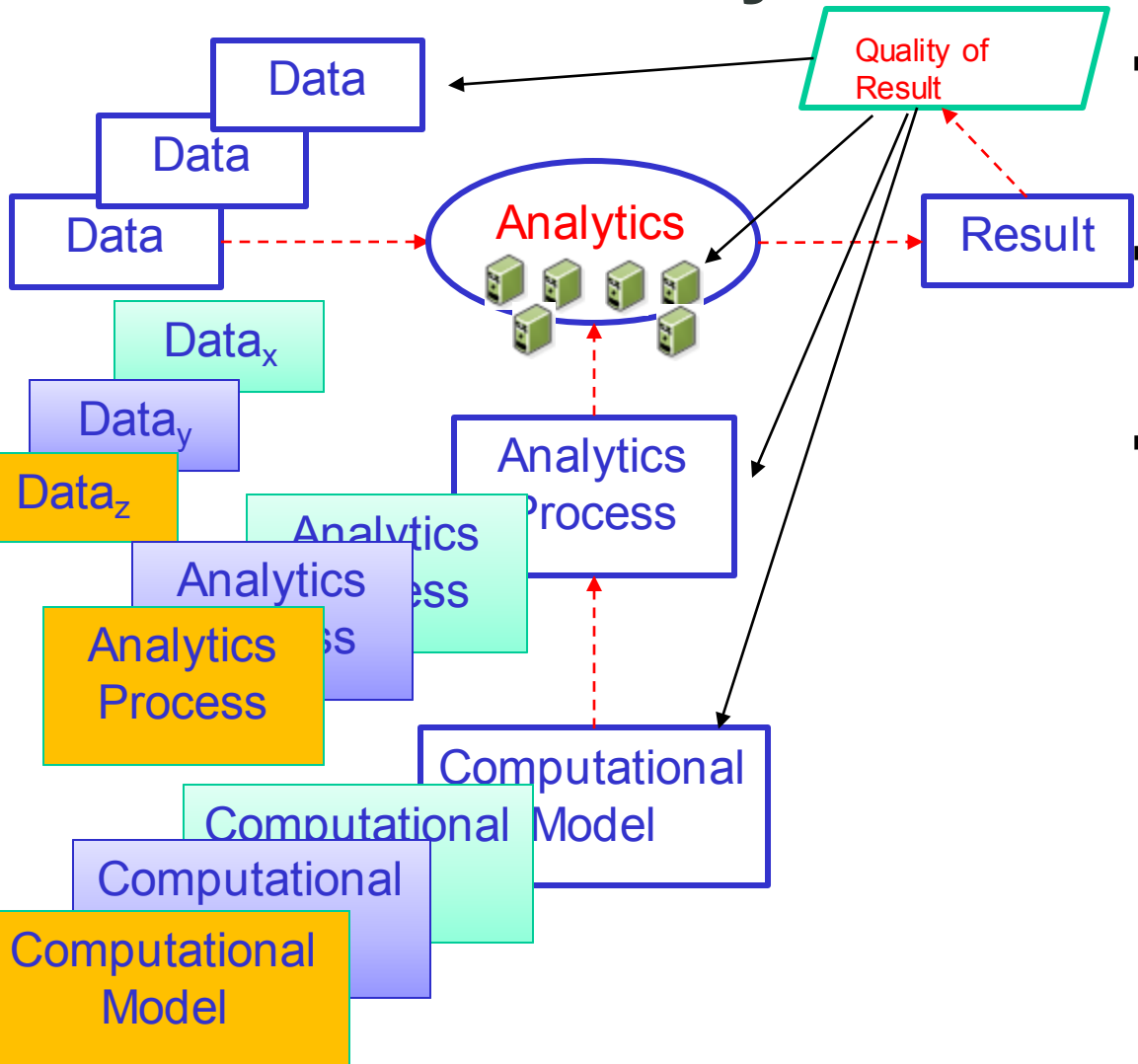
Software-defined APIs

Hong-Linh Truong, Schahram Dustdar, Georgiana Copil, Alessio Gambi, Waldemar Hummer, Duc-Hung Le, Daniel Moldovan, "CoMoT - a Platform-as-a-Service for Elasticity in the Cloud", (c) IEEE Computer Society, IEEE International Workshop on the Future of PaaS (PaaS2014), 2014 IEEE International Conference on Cloud Engineering (IC2E 2014), Boston, Massachusetts, USA, 10-14 March 201

# Internet-scale service engineering - - the elasticity



# Internet-scale service engineering – the elasticity



- **More data** → more computational resources (e.g. more VMs)
- **More types of data** → more computational models → more analytics processes
- Change **quality of analytics**
  - Change quality of data
  - Change response time
  - Change cost
  - Change types of result (form of the data output, e.g. tree, visual, story, etc.)



# Internet-scale service engineering - - big/near-real time data impact

- Which are data concerns that impact the data processing?
- How to use data concerns to optimize data analytics and service provisioning?
- How to use available data assets for advanced services in an elastic manner?
- What are the role of human-based services in dealing with complex data analytics?

# Internet-scale service engineering - - Steps

## Single service/platform engineering

Service units for representing fundamental things, people and software

Provisioning of fundamental service units

Engineering with single service units



## Understanding Properties/Concerns

Data /Service/Application concerns; their dependencies

Monitoring, evaluation and provisioning of concerns

Utilization of data/service concerns



## Large-scale, multi-platform services engineering

Identify platform/application problems

Identify the scale, complexity and \*city

Design units, selection of existing service units;

Development and integration, optimization

- Read papers mentioned in slides
  - Get their main ideas
- Check services mentioned in examples
  - Examine capabilities of the mentioned services
    - Including price models and underlying technologies
  - Examine their size and scale
  - Examine their ecosystems and dependencies
- Work on possible categories of single service units that are useful for your work
  - Some common service units with capabilities and providers

# Thanks for your attention

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