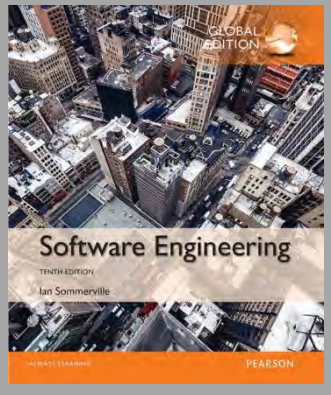


SOFTWARE ENGINEERING FOR SERVICE-ORIENTED ARCHITECTURE

LEEDS BECKETT UNIVERSITY

Dr Muthu Ramachandran, FBCS, FHEA, Principal Lecturer, SETEP Research Group Lead, School of Computing, Creative Technologies, and Engineering (CCTE), Leeds Beckett University, Email: m.ramachandran@leedsbeckett.ac.uk, BCS EA SIG Conference, 17th July 2017, BCS London.

Synopsis/Main Theme

- Service and cloud computing has revolutionized the way we develop software. The emergence of cloud computing has huge impact on the economics of developing services.
- However, it remains challenging to understand the concept of a service which is quite new for computing sciences.
- This talk will present a systematic approach to understanding service and cloud computing and will provide a Service Development Life Cycle approaches and market niche techniques and tools.

In this Lecture, discover

- Leeds Beckett University and Computing Research
- **Part 1: What & Why SOA?, Service Computing, Cloud Computing, IoT, Big Data, Wireless Sensor Networks**
  - Definition & Introduction
  - SOA Architecture & Applications
  - Cloud Computing
- **Part 2: Cloud Software Engineering vs Software Engineering for the Cloud**
  - Cloud Service Requirements Engineering
  - Cloud Service Design
  - Cloud Service Development & Deployment
  - Cloud Service Testing
- **Part 3: SOA & Cloud Development Process & Standards**
- Reading List & References

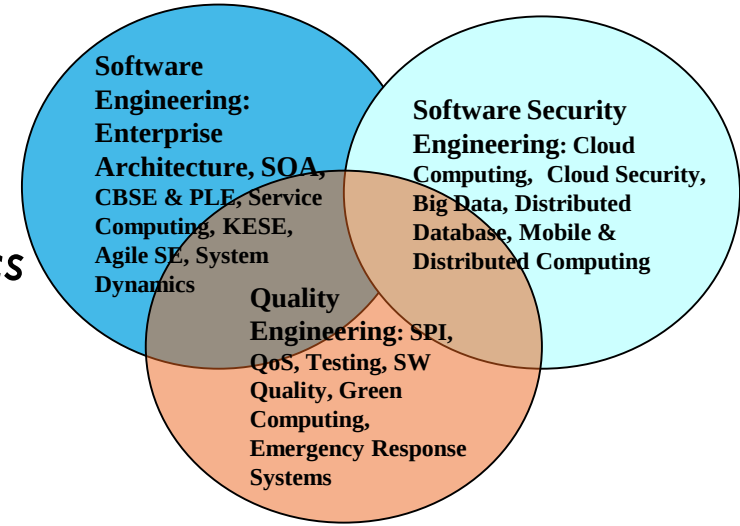
Leeds Beckett University

- **Leeds Beckett is the fifth best uni in the country for producing CEOs**
- **Beckett breeds more business leaders than Oxford, LSE or Leeds Uni**
- The data, released by Emolument, studied 26,000 graduates across the UK – and found that Beckett produces 3.1 per cent of the UK's CEOs, CTOs and Partners.

LEEDS BECKETT UNIVERSITY

Research Groups at Leeds Beckett

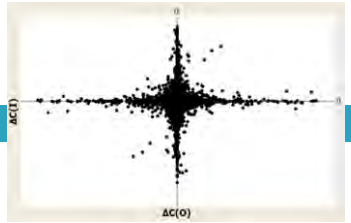
- *Software Engineering, Technologies, and Emerging Practices (SETEP) Group (Lead by Muthu)*
- *Assistive technologies and computer forensics and security*
- *IT and sustainability*
- *Data mining, big data and AI*



Holistic approach to computer science research

LEEDS BECKETT UNIVERSITY

Current & Some Previous Projects



Example of a complex code analytics

- Software Engineering – Reuse Framework, Component Model for Complex Systems, used in various Industries including Philips, Image Systems, Volantis Systems Research, etc., SPI, Testing, Software Product Line Engineering, Maturity model for CBSE and SOA
- Cloud Computing and Big Data – Cloud Computing Adaption Framework (CCAF, IEEE SC 2016), Dynamic Service Component Model, Big Data and Resiliency Framework (FGCS 2015)
- **SE for SOA and Cloud: Enterprise Architecture, Agile SE, SOA, Design and Architecture Security, Big Data Architecture**
- Software Security Engineering Research: Vulnerability Techniques, Security Improvement, Design for Software Security

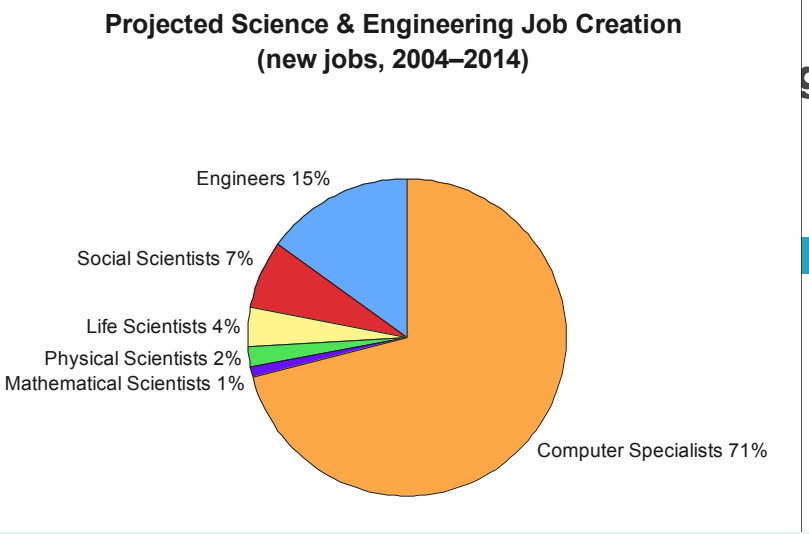
LEEDS BECKETT UNIVERSITY

www.soft-research.com

Current Research: Software Engineering as a Service (SEaaS)

- Software Requirements Engineering as a Service- Software security requirements management as an emerging cloud computing service (IJIM paper April 2016)
- Software Project Management as a Service (Collaboration with National Institute of Technology Karnataka, Surathkal Mangalore - Karnataka, India, http://www.nitk.ac.in/people/k-chandrasekaran
- Quality of Service (QoS) as a Service
- Software testing as a Service (STaaS)

Wh… g Research?



As we can see, there is a continued skill shortage and a rapid change in software technology is faster than predicted. Why SE for Service and Cloud Computing?
Remember, boom and burst of dot com in the early 2000 and failures of software systems and cybersecurity attacks (we can't protect systems by adding security patches we have design for it) suggests lack of adopting systematic approach to developing services.

My Personal Moto Learned from childhood : As Avvaiyar (a Tamil Lady poet from 1st-2nd Century of C.E (roughly 2000 years ago Common Era or A.D) wrote (wikipedia):

"Katrathu Kai Mann Alavu, Kallathathu Ulagalavu"

meaning roughly "What you have learned is only a handful; What you haven't learned is the size of the world"

NASA link to Avvaiyar from 4th Century

PART 1: WHAT & WHY SOA?, SERVICE COMPUTING, CLOUD COMPUTING, IOT, BIG DATA, WIRELESS SENSOR NETWORKS

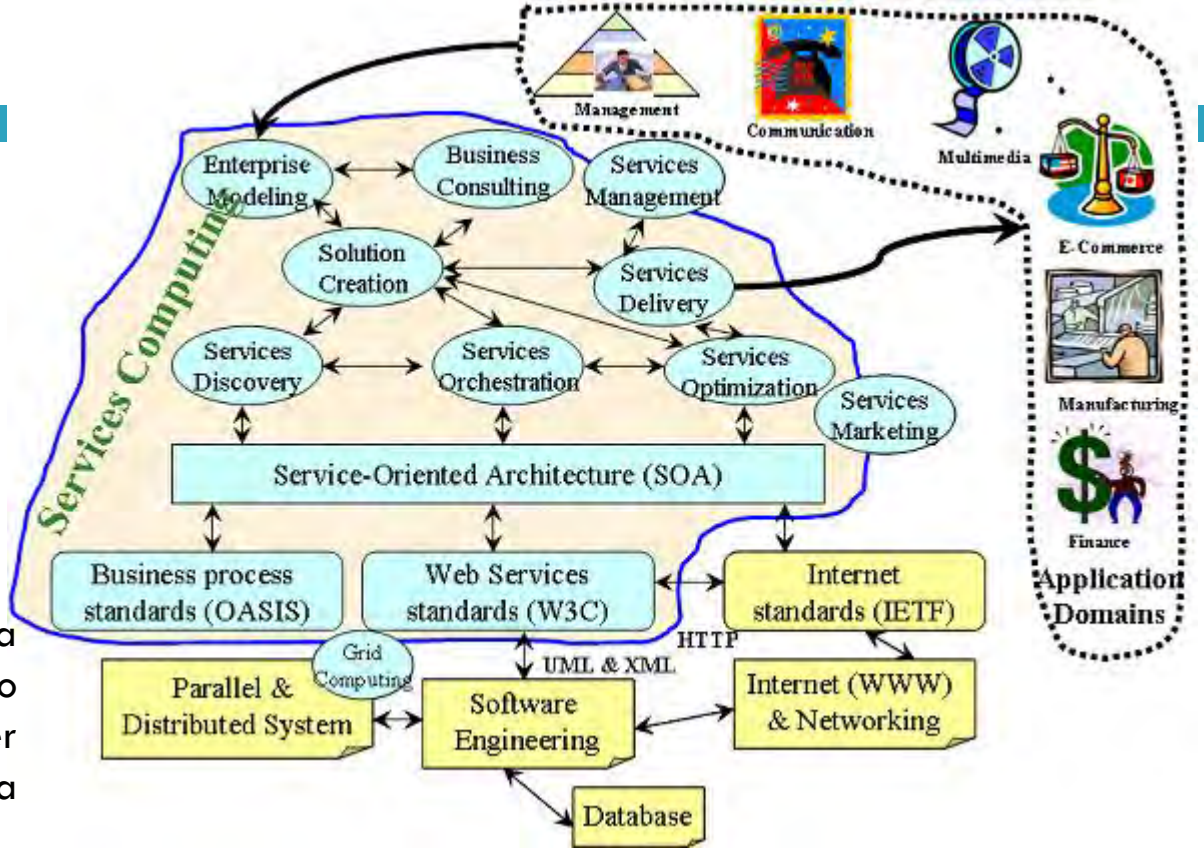
What is SOA (So-Ah)?

- ebizQ http://www.youtube.com/watch?v=sRFwswaJpD0
- Prof Paul Strassmann http://www.youtube.com/watch?v=nRayJZmj2oY&feature=related
- Fundamentals of service delivery platforms – excellent foundation to SOA must watch video talk Fundamentals of service delivery platforms http://www.youtube.com/watch?v=m1z22GFvsYg
- Kent Mitterer http://www.youtube.com/watch?v=jl5oFtNwJ9Q&feature=related
- Why study SOA? Technology transition; Increasingly software is moved to service oriented (see presence of web service and cloud computing)
- Excellent Introduction to SOA By Marco Di Stefano (prezi presentation) http://www.refactoringideas.com/an-soa-presentation/
- 2015 CEFRIEL - Service Centric Systems Engineering (SeCSE)

What is SOA? Is it a New Science and Engineering?

My definition: SOA is a way of architecting and structuring software assets, components, and services using message passing as the core design principle to maximise reuse.

SOA is a logical way of designing a software system to provide services to either end-user applications or to other services distributed in a network, via published and discoverable interfaces.



Common Sense Definition

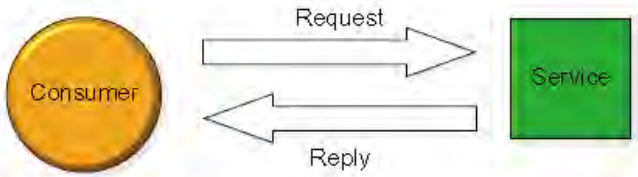


FIGURE 1.2

SOA Consumer and Service

FIGURE 1.3

SOA Consumer, Intermediary, and Service

Why SOA? Service Computing of Everything: Internet of Everything (IoE)

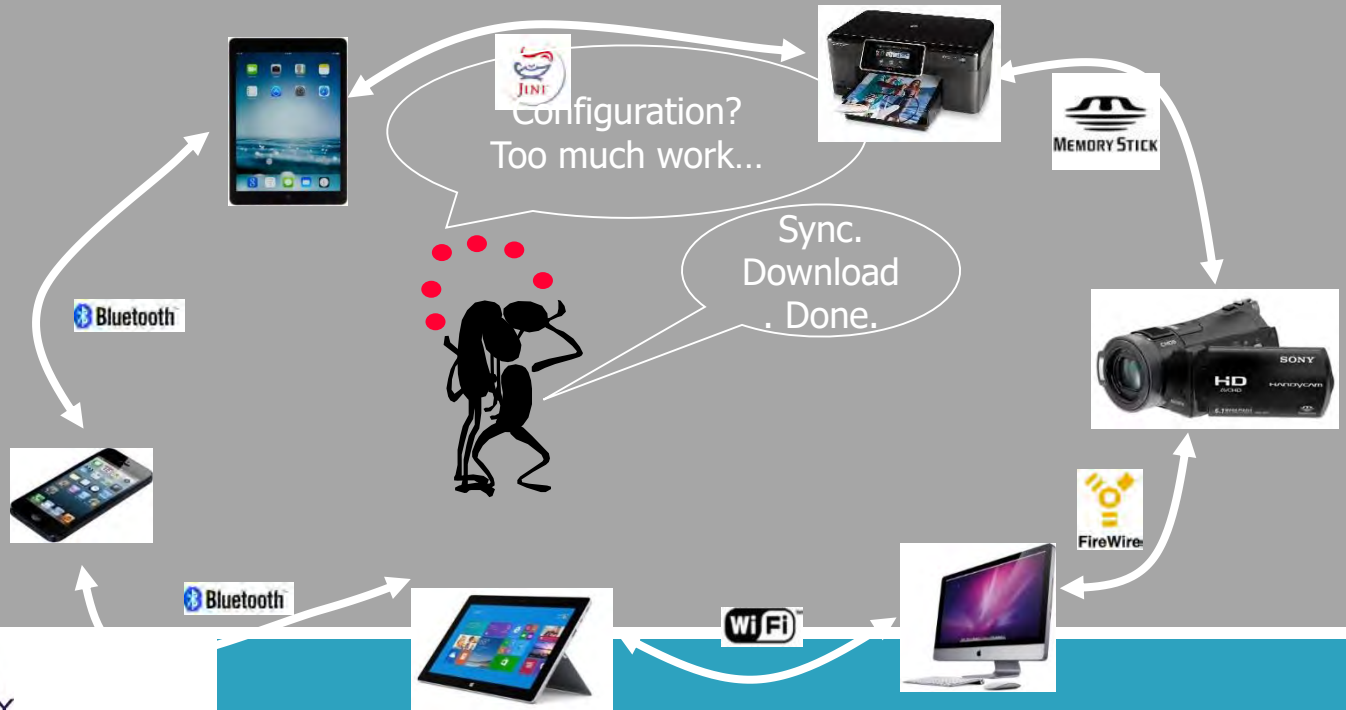
The Future is here!

Why SOA? Multitude of devices, seamless data, intelligence, multitude of software, systems, services, and platform integration, and predictions. The Future is here!

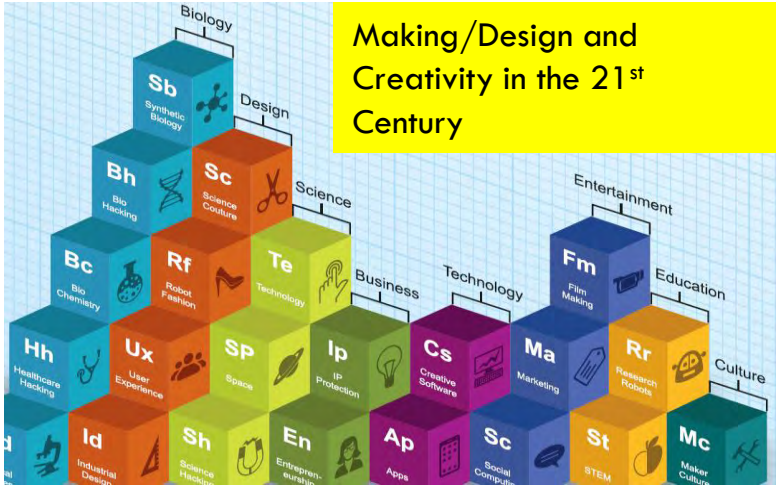
SOA is a formalised way of integrating applications existing traditional applications and legacy systems) into an enterprise architecture and hence suitability for connecting IoEs

YESTERDAY: GADGETS ARE EVERYTHING

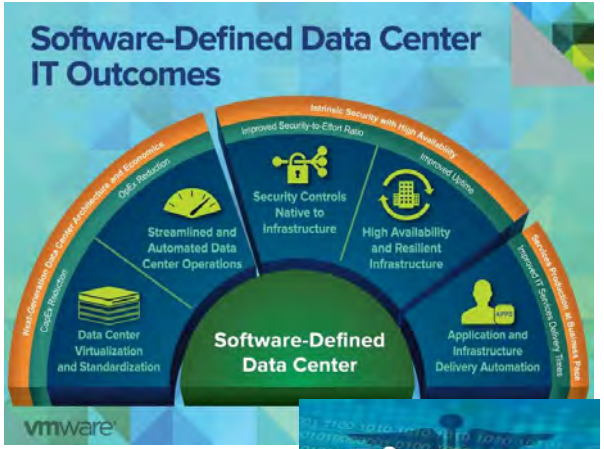
TODAY: COMMUNICATION IS EVERYTHING



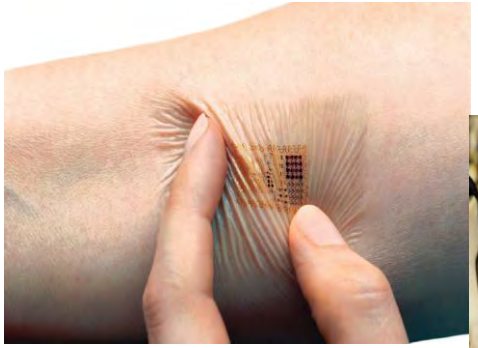
Tomorrow: Service is Everything: they communicate, compose new services, and self recover themselves



Making/Design and Creativity in the 21st Century



3D-printed "science" necklace: Making in the 21st Century, Computer Dec 2014



MC10's Biostamp: wireless health reading data

A Robot Penguin chick to monitor others (IoT)

Universal Theme: Seamless Data, intelligent and ubiquitous interactivity is a key theme across all sectors

Manufacturing: Intelligent interconnectivity across the enterprise for enhanced control, speed and efficiency (**Industrial IoT**)

Retail: Highly personalized customer experience across channels and devices

Seamless, Intelligent and Ubiquitous Interactivity

Healthcare: Integrated and smart patient care systems and processes

Banking and Finance: Seamless customer experience across all banking channels

Automotive:
V2V and V2I communication, Automatic Cars emerging into market much faster than predicted

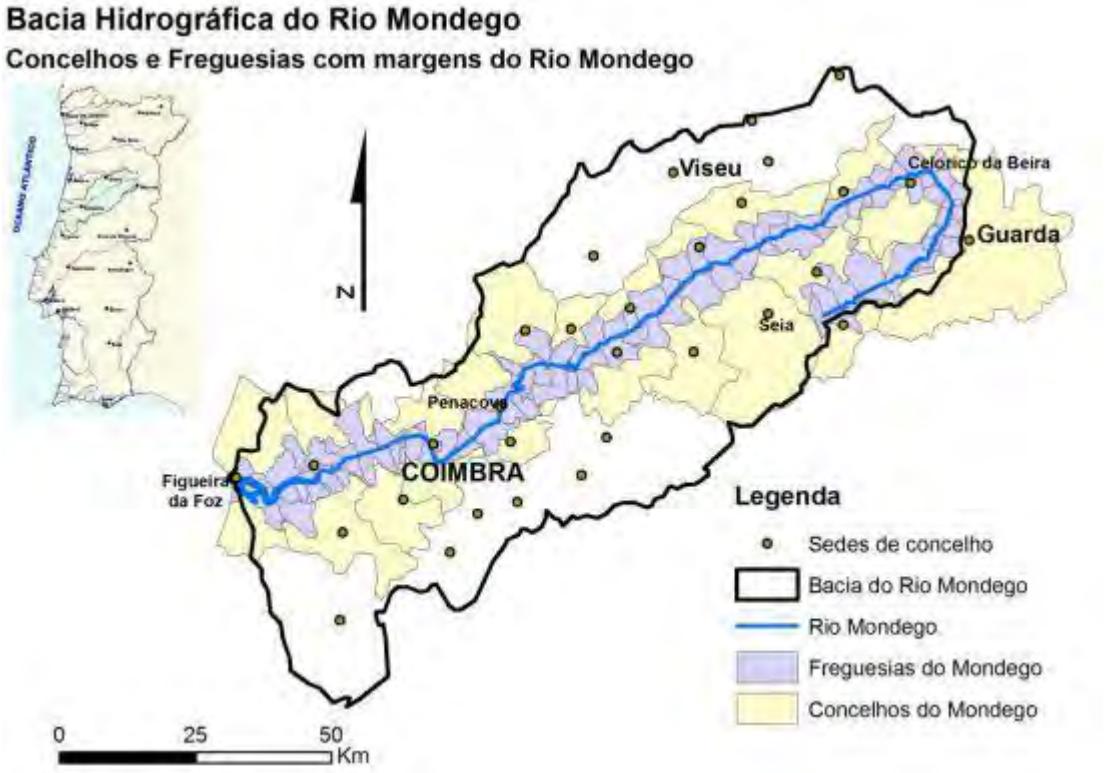
LEEDS BECKETT UNIVERSITY

Wireless Sensor Networks

Natural Flood & Fire Disasters

Application of Service and Cloud Computing

Bacia Hidrográfica do Rio Mondego

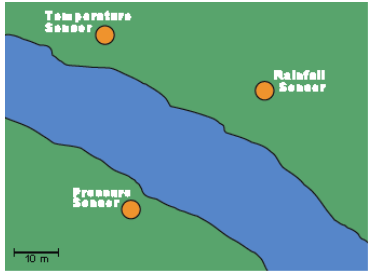


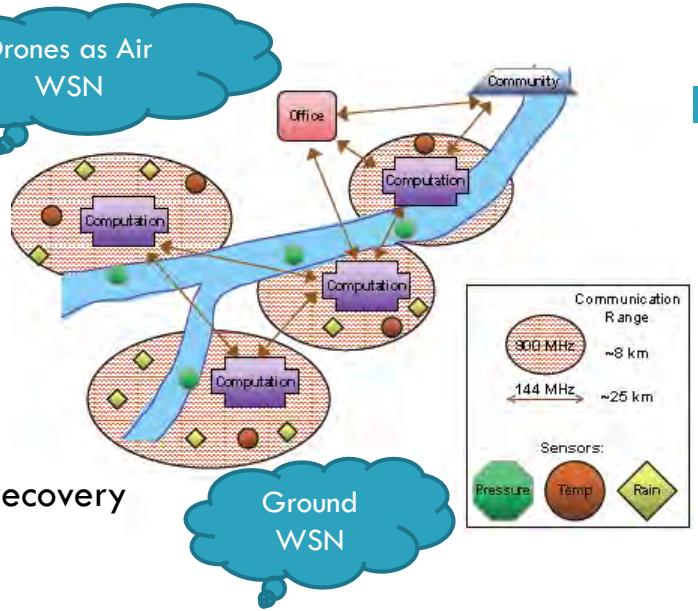
LEEDS BECKETT UNIVERSITY

Wireless Sensor Network (WSN) for Predicting Natural Disasters

Bacia Hidrográfica do Rio Mondego (a river in Portugal)

Challenges of intelligent computational IoT sensors





Challenges on Networked WSN and use of Drones for during and recovery phase of natural floods disasters.

- Optimal energy usage of sensors
- Computational Intelligence and Data Analytics – Some predication models to be built-in
- Three types of sensors: Temperature, Rainfall, and Pressure
- Ongoing project with Portugal and other partners

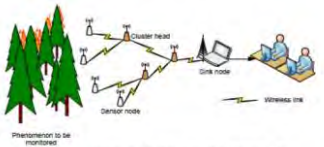
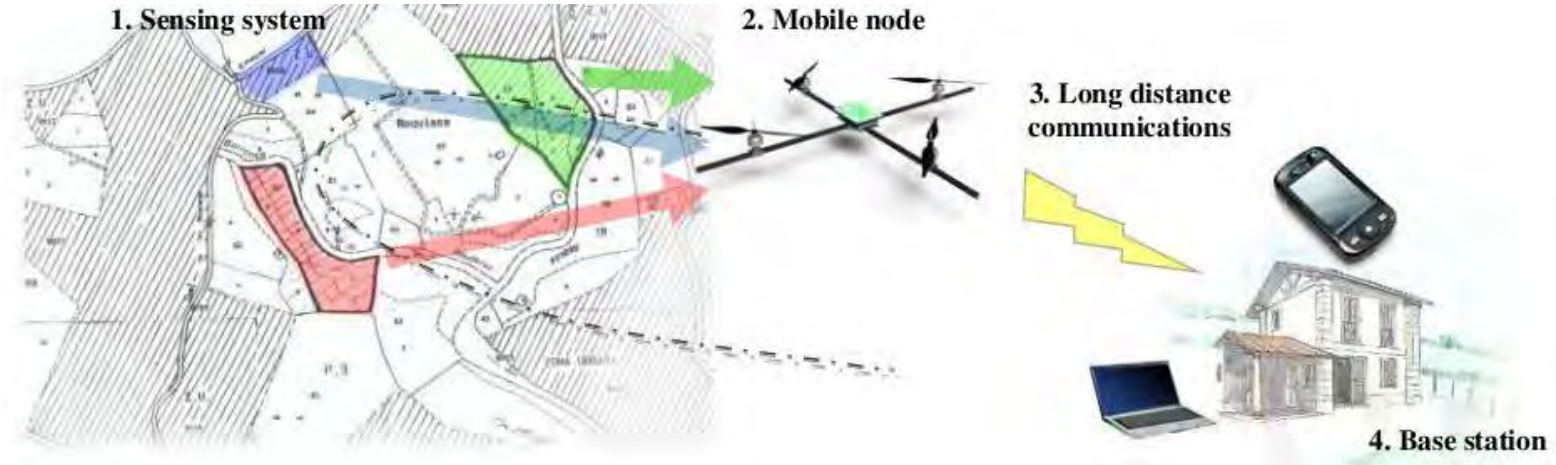


Figure 1.1 Architecture of a Typical WSN

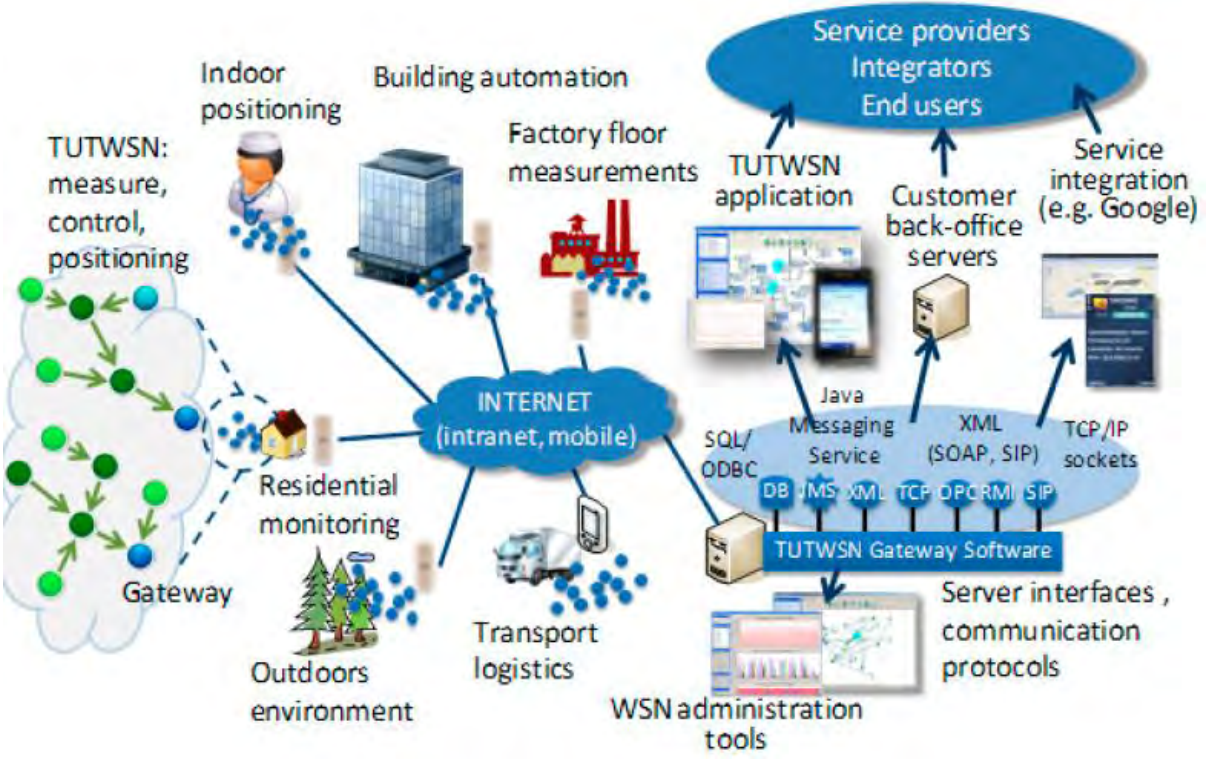
LEEDS BECKETT UNIVERSITY

Use of Drones for Air Surveillance, Monitoring and Recovery: Floods, Fire Recovery, Crops Monitoring



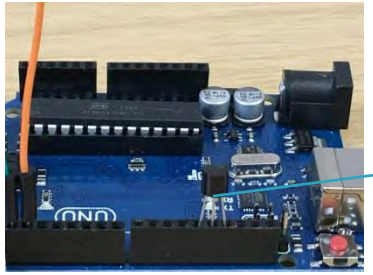
The architecture of a typical wireless sensor network

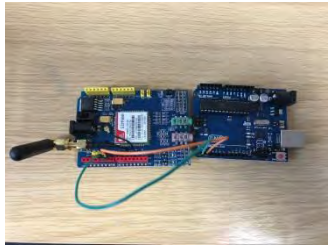
Chen, H (2016) et. al. An Efficient Recommendation Filter Model on Smart Home Big Data Analytics for Enhanced Living Environments, Sensors 2016, 16, 1706; doi:10.3390/s16101706, www.mdpi.com/journal/sensors



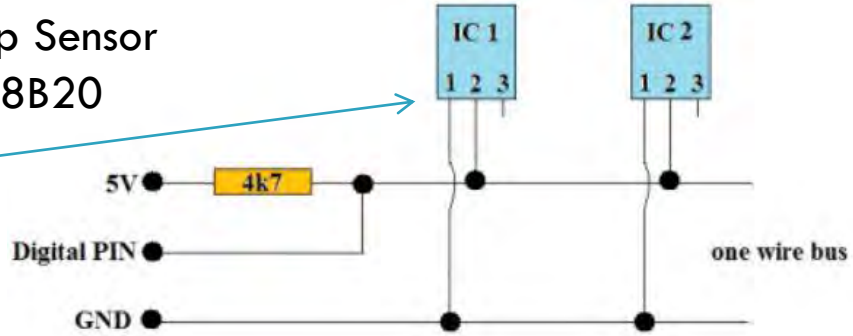
LEEDS BECKETT UNIVERSITY

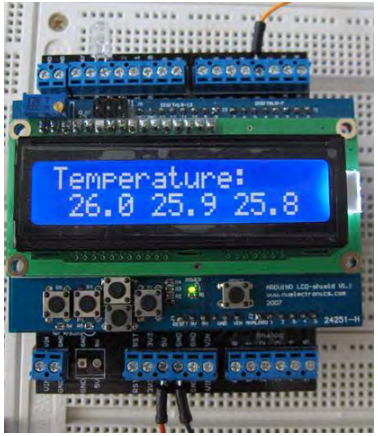
WSN/IoT for Fire Alert





Temp Sensor
DS18B20





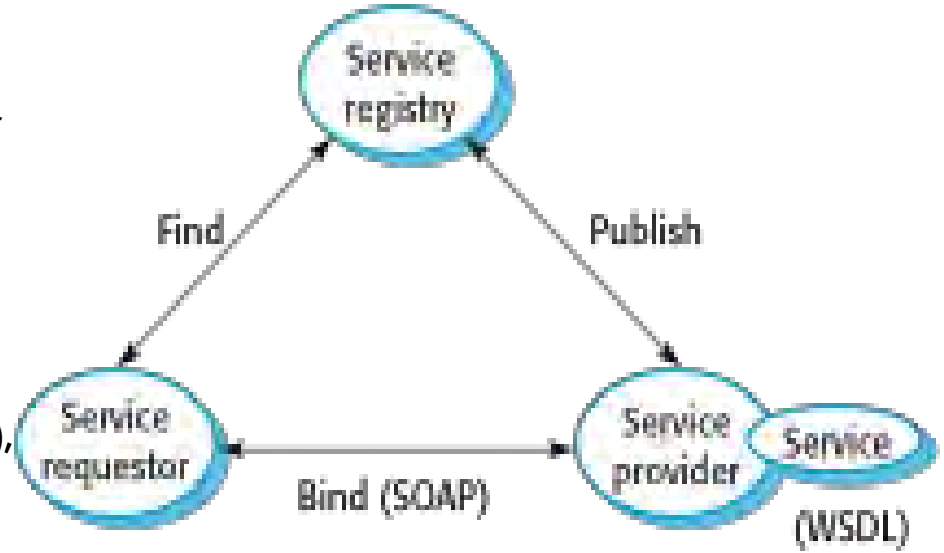
Arduino Processor with GSM Module and Temperature Sensor DS18B20

http://www.instructables.com/id/Temperature-with-DS18B20/

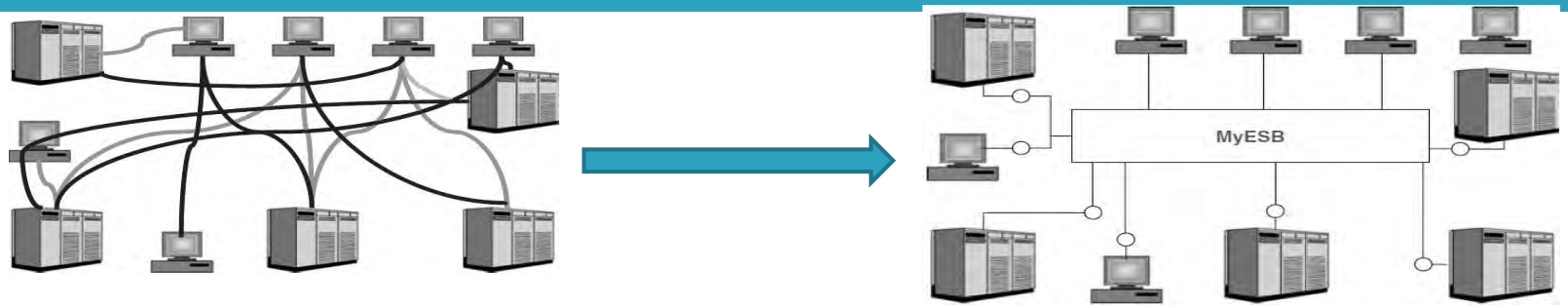
Publish, Find, Bind and Execute Paradigm of SOA

Service Providers build services and offer them via an intranet or Internet. They register services with service brokers and publish them in distributed registries. Each service has an interface, known as contract and functionality, which is kept separate from the interface. The Service Consumers search for services (based on some criteria) - when found, a dynamic binding is performed. In this case, the service provides the consumer with the contract details and an endpoint address. The consumer then invokes the service.

Services, implemented as Web Services (WS) are delivered using technologies such as eXtensible Markup Language (XML), Web Services Description Language (WSDL), Simple Object Access Protocol (SOAP) and Universal Description Discovery and Integration (UDDI).



Enterprise Service Bus (ESB)



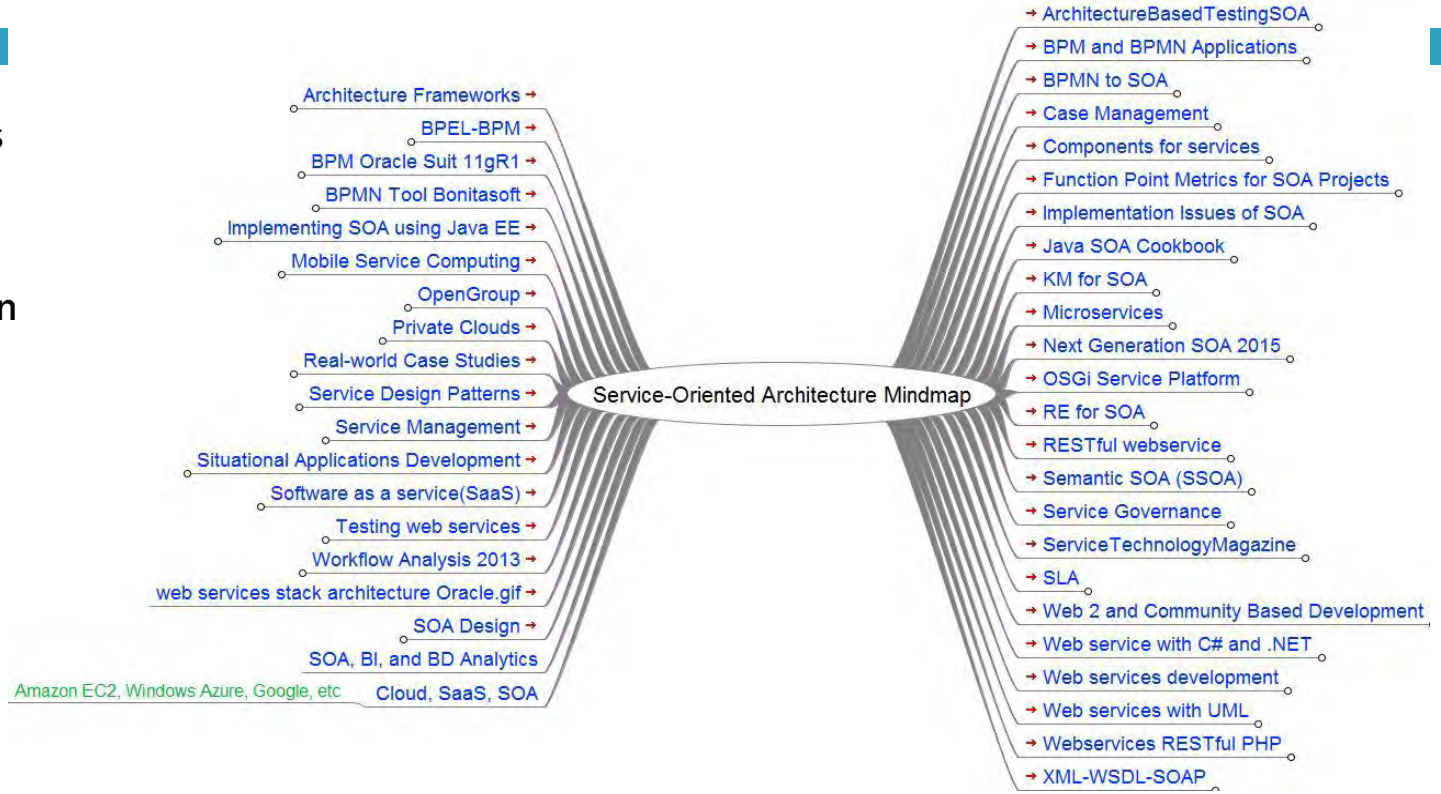
Enterprise spaghetti

ESB

Enterprise Service Buses (ESBs) build on MOM (message-oriented middleware) to provide a flexible, scalable, standards-based integration technology for building a loosely coupled, highly-distributed SOA. ESBs contain facilities for reliable messaging, web services, data and message transformation, content-based 'straight through' routing. Along with web services, ESBs are proving to be the major technical enablers for actual SOA projects.

SOA Research Challenges & Landscape 2016

Some key challenges are: Enterprise Integration, Service Reuse, Service Design Patterns, Service management, SE for SOA, Metrics, Architecture Driven Services, Design for Service Security



Research Landscape Link

PART 2: SE FOR CLOUD COMPUTING VS CLOUD SE

SE for Cloud vs Cloud SE

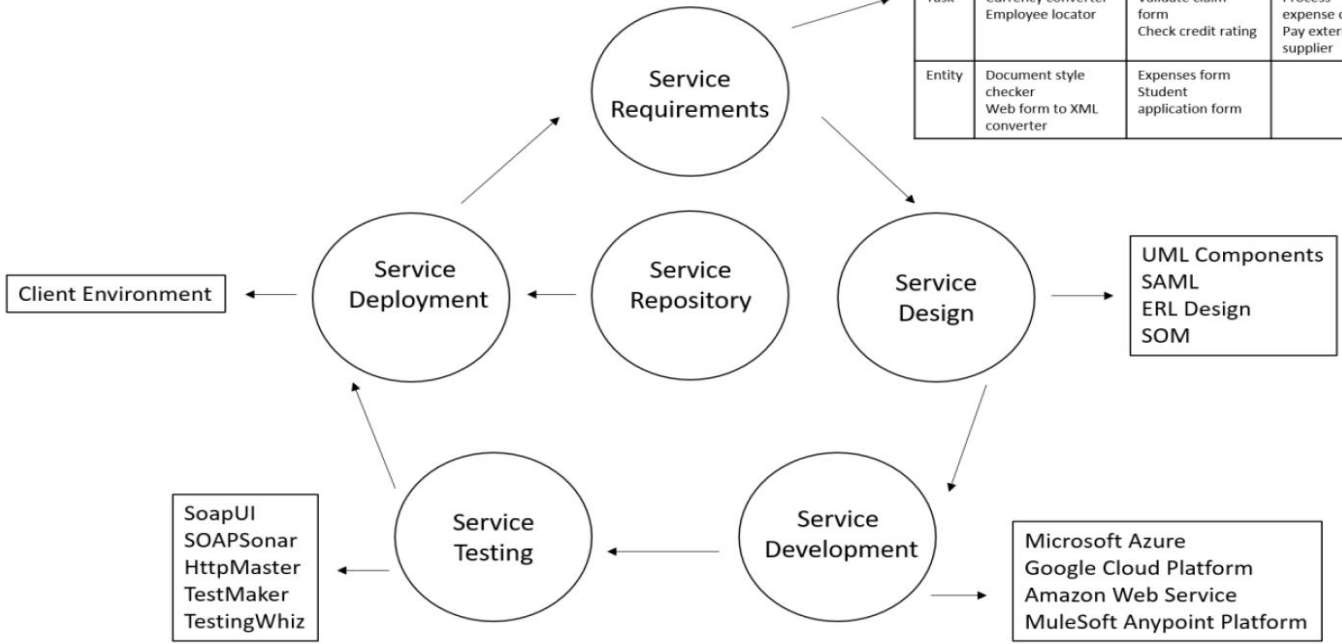
- **SE for Cloud Data Centres (DC)** should focus on engineering approaches to design and development of cloud data centres: service development process, methods, developing reusable services, systematic approaches to cloud deployment, management, pricing, design for scalability, elasticity and sustainability that needs to be build-in, tested and deployed by **cloud providers**
- **Cloud SE** should focus on engineering approach to developing new services offered by a cloud with emphasis on build-in for scalability, service reusability, and elasticity.

Challenges for Cloud Software Engineering

- **Systematic SE Approach**: Build a software development environment that radically simplifies hosting scientific applications on a range of clouds (Cloud federation & Multi-clouds)
- **Service Reuse**: Build applications that make use of the cloud providers APIs (PaaS) to access common services.
- Challenge is using existing PaaS APIs for computationally-intensive applications
  - Systems are set up to support web-based applications
  - Google Apps – 30 second time limit on tasks
  - Significant application change required
- **Service Reuse & Design for Scalability**: Investigate how to adapt applications that are computation/data intensive to run within the constraints set by the PaaS interfaces from cloud providers
- **Design for Architecture Reuse**: Application architecture designed for the cloud: Underlying infrastructure management done in the program itself, depending on performance and cost requirements. What abstractions do we need for this?
- **Three grand challenges**
  - Programming models for the cloud
  - Building a PaaS for high performance/ throughput computing
  - Cloud-aware software development environments
- Reference: Sommerville, I (2012) Challenges for cloud software engineering, http://pire.opensciencedatacloud.org/talks/Cloud-Software-Challenges.pdf

Service-Oriented Software Engineering

	Utility	Business	Coordination
Task	Currency converter Employee locator	Validate claim form Check credit rating	Process expense claim Pay external supplier
Entity	Document style checker Web form to XML converter	Expenses form Student application form	

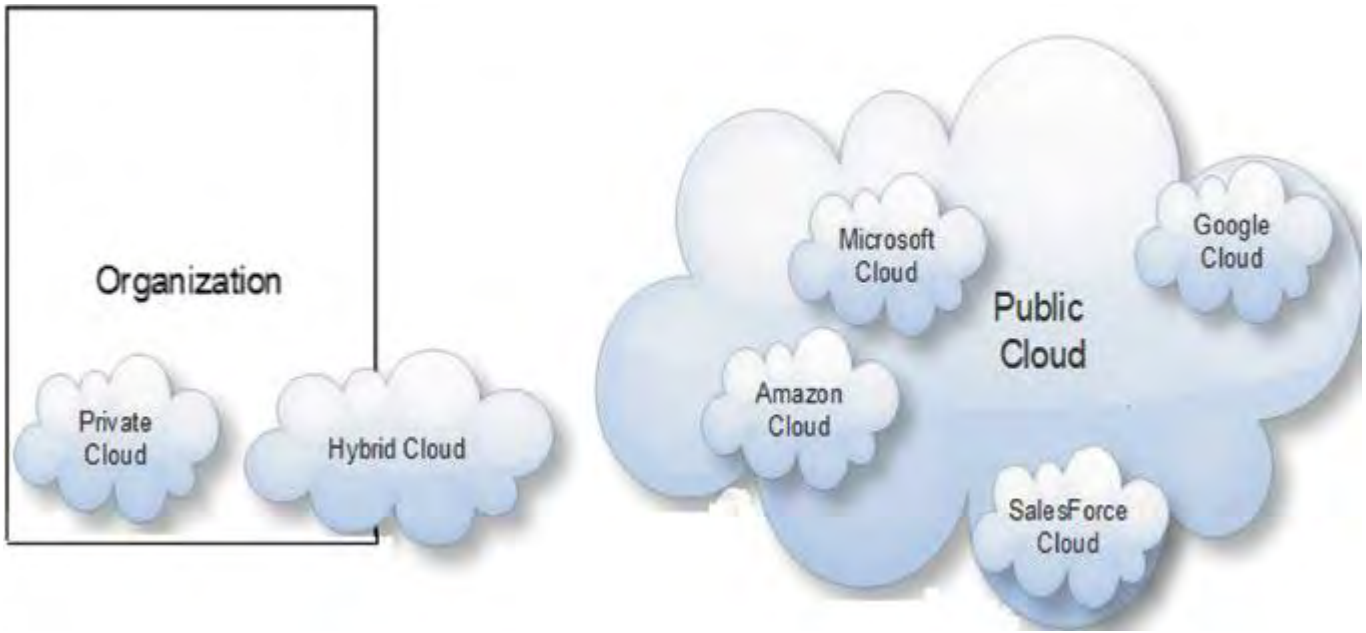


Programming models for the cloud: yet another cloud programming language?

- Are there programming models that can take advantage of elasticity and massive parallelism?
- – Invent new models for parallel computation
- – Adapt existing problems to the current map/reduce programming model
- How do we adopt efficient cloud resource management algorithms?
- What about energy efficiency of the clouds?
- How do we cater for multi-tenancy and pricing models?

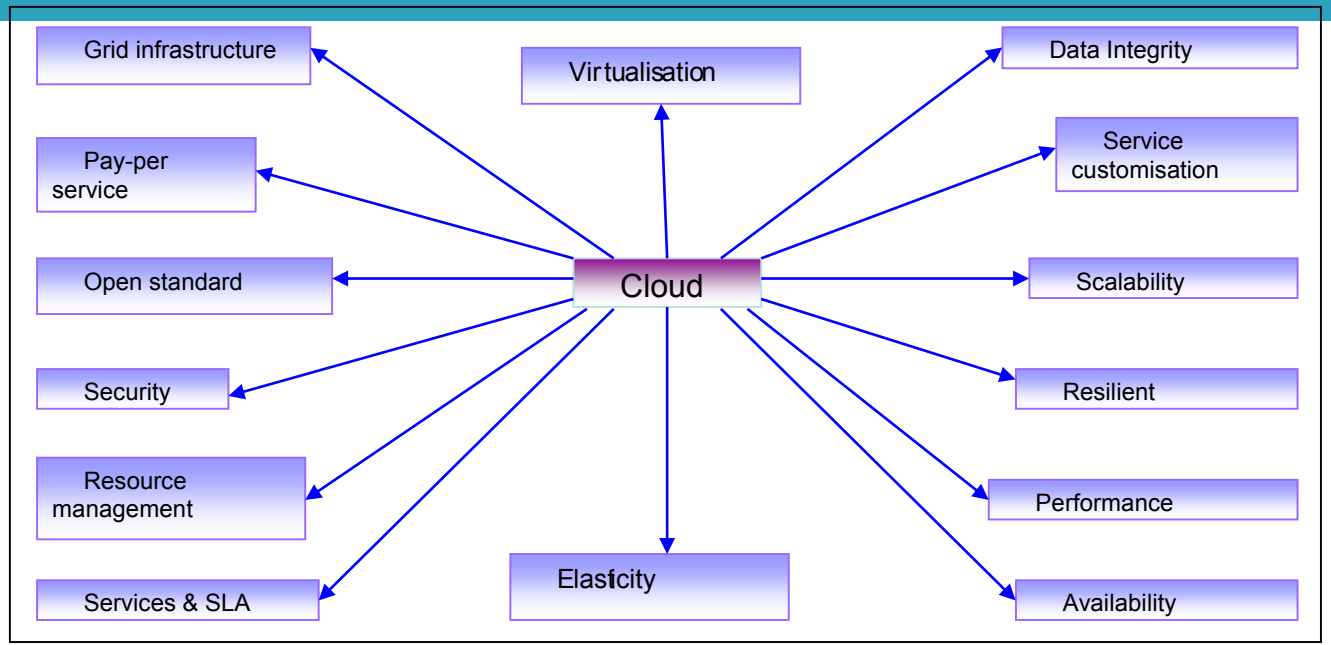
Cloud Computing

Introduction to Cloud



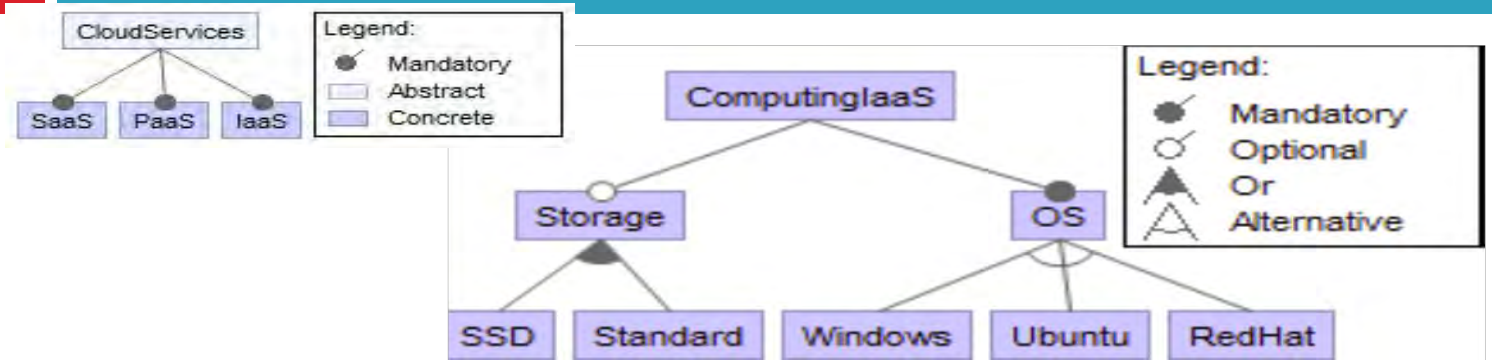
https://app.box.com/s/h0thc07ulmpr4g4s12penhg9f6us44td

Cloud Characteristics



Cloud Services

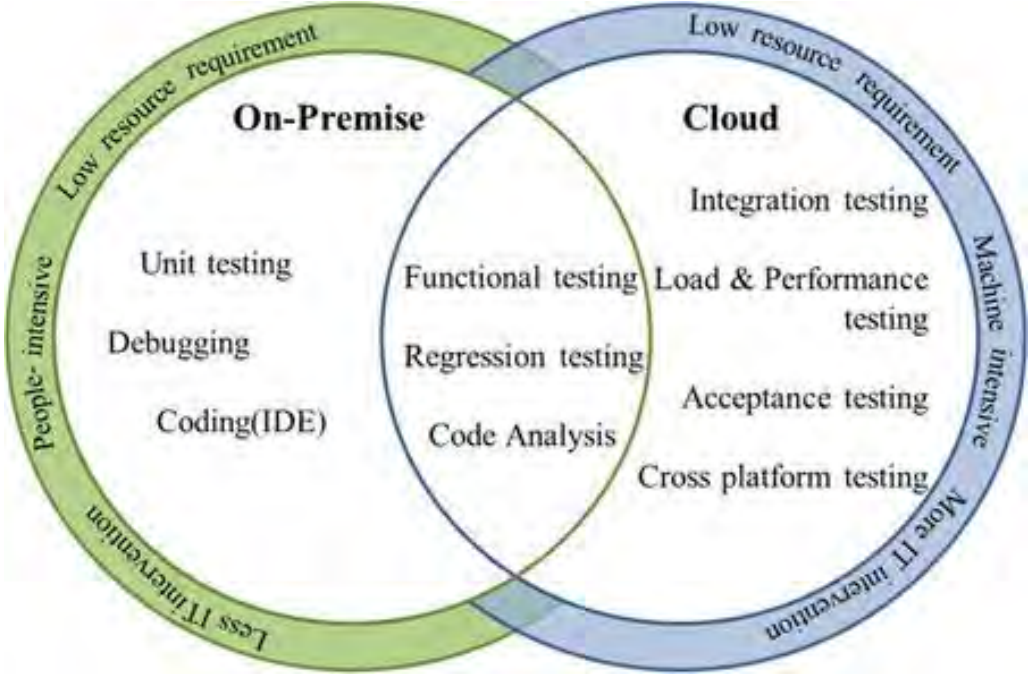
Feature model for a Cloud Infrastructure as a Service (IaaS)



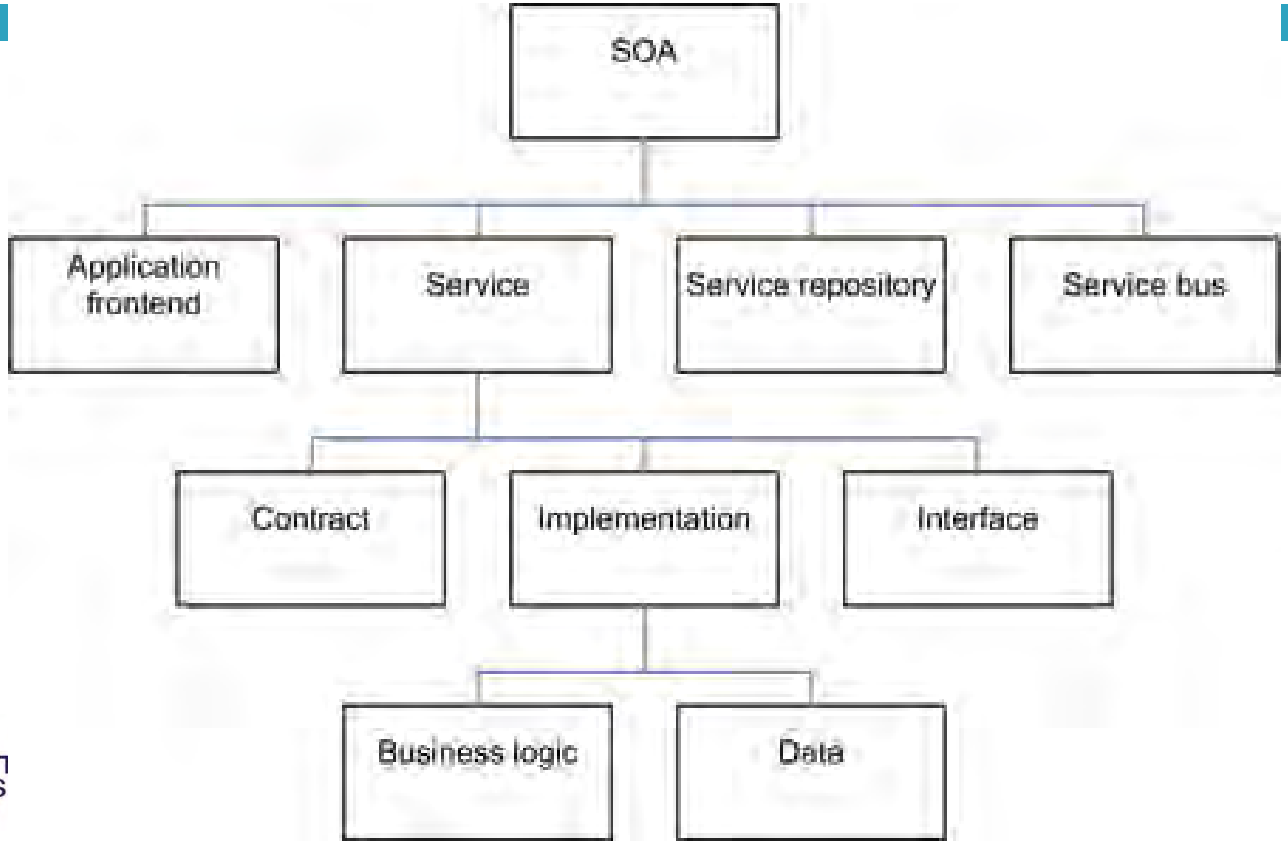
Exercise 1: Draw a feature model for Amazon AWS services: EC2 and S3 services http://aws.amazon.com/

Exercise 2: Draw a feature model for Microsoft Windows Azure cloud services http://azure.microsoft.com/en-gb/

Key software development activities— on-premise versus cloud



SOA Development Structure



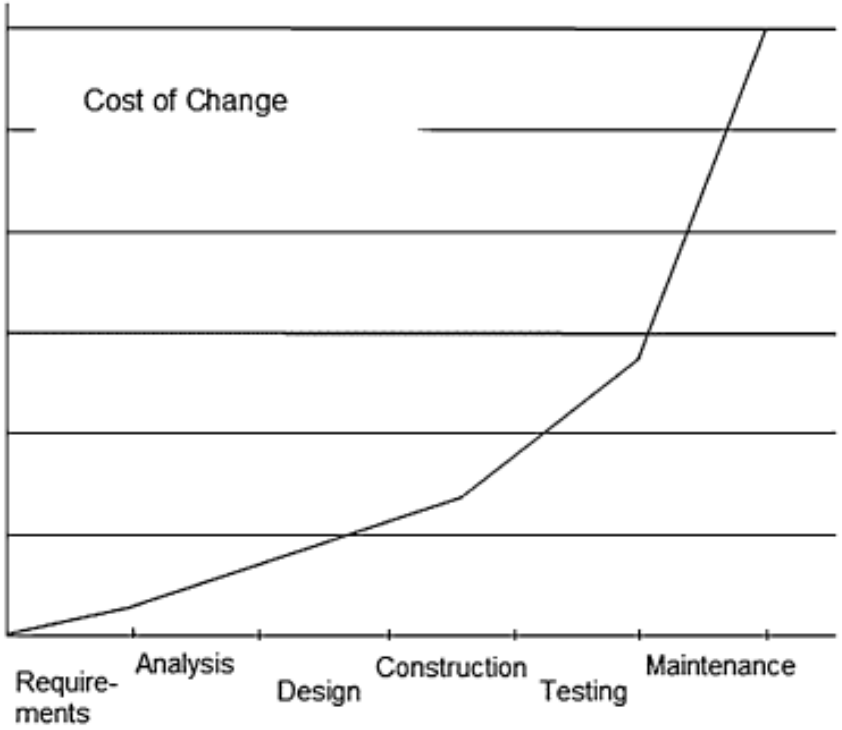
Cloud SE

Cloud Project Management: Service Cost Estimation and Cloud Economics

Economics for traditional SDLC

Incorporating changes at a later stage of SDLC increases the cost of the project exponentially

Adding more number of programmers at a later stage does not solve the schedule problem as increased coordination requirement slows down the project further. It is very important that requirements gathering, planning, and design of the software are done involving all the parties from the beginning.

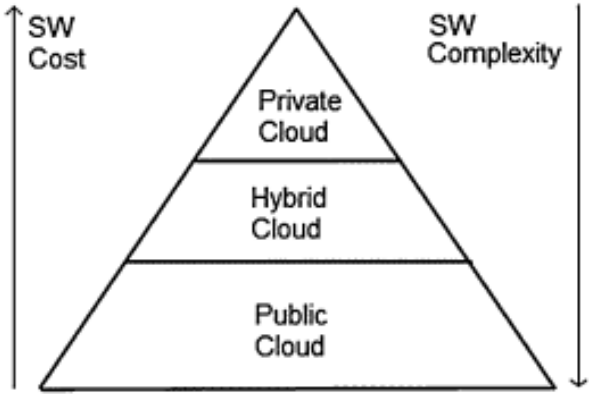


Impact of Cloud Computing on Software Engineering

- Existing software process models and framework activities are not going to be adequate unless interaction with cloud providers is included.
- The cloud providers can help in answering these questions about
  - (1) how many developers are needed, (2) component reuse,
  - (3) cost estimation, (4) schedule estimation, (5) risk management, (6) configuration management, (7) change management, and (8) quality assurance (QoS)
- Instead of KOLC/FP (Function points) – service points metrics?

Economics of cloud SE: complexity of service engineering

Especially when applications are deployed as “software as a service” or “SaaS” model, they may have occasional workload surge not anticipated in advance.



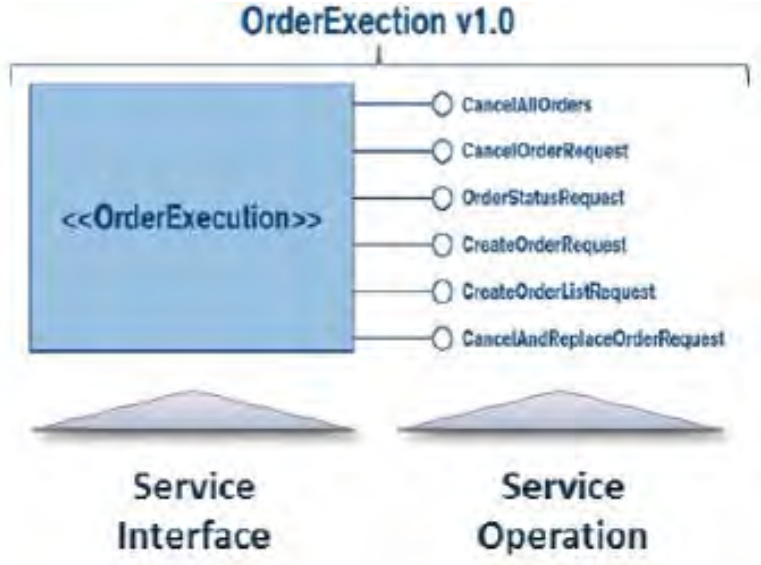
Service Cost Estimation Techniques

Service Point Estimation

A Service is a unit of solution logic to which service-orientation has been applied to
a meaningful extent. It is a container for a collection of related functions.

$$Service\ Point\ (SP) = \sum_{i=1}^{n} (Pi \times P)$$

Where Pi is an infrastructure factor with empirical value that is related to the supporting infrastructure, technology and governance processes. P represents a single specific service's estimated size that varies with different service types, including existing service, service built from existing resources, and service built from scratch.

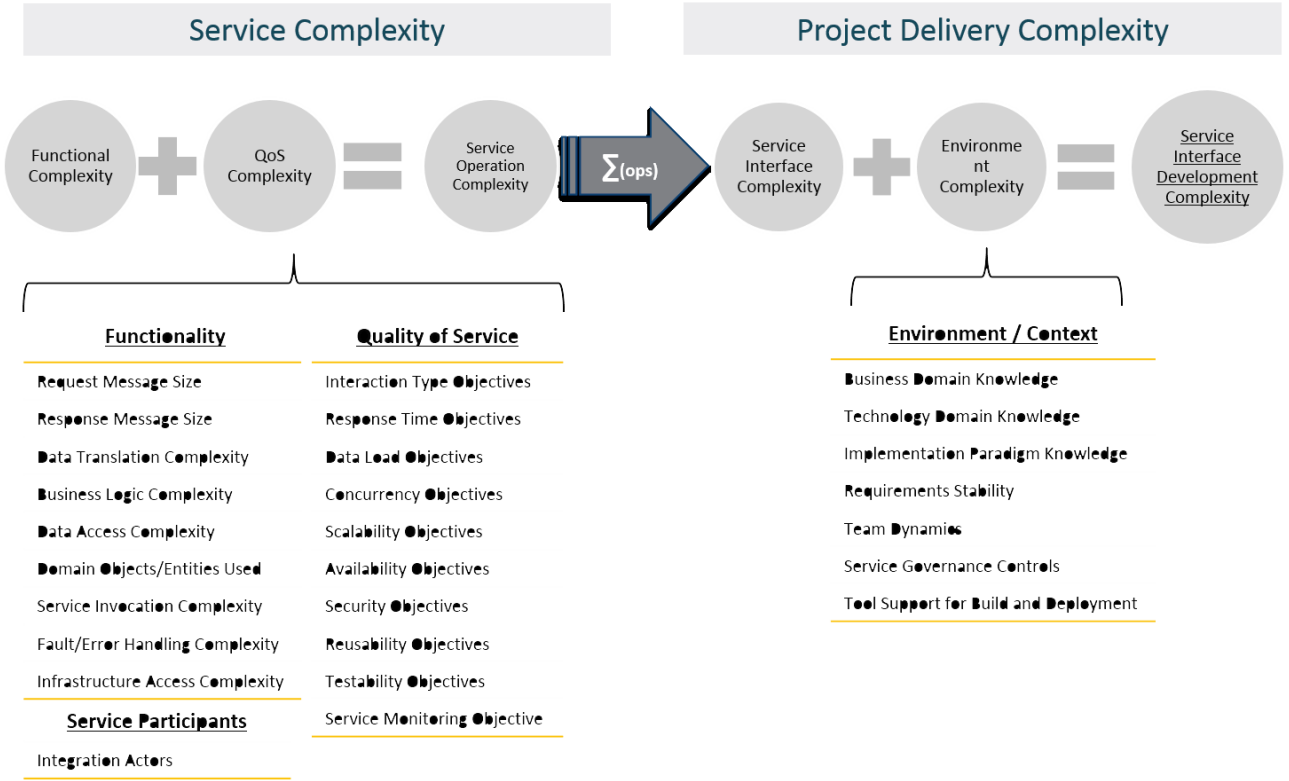


Gupta, D (2013) Service Point Estimation Model for SOA Based Projects, http://servicetechmag.com/system/application/views/I78/1113-1.pdf

Other approaches

Cost of SOA = (Cost of Data Complexity + Cost of Process Complexity + Cost of Service Complexity + Enabling Technology Solution)

Service Complexity vs. Project Complexity



LEEDS BECKETT UNIVERSITY

Cost estimation for cloud services

Table 1.2 COCOMO [29]

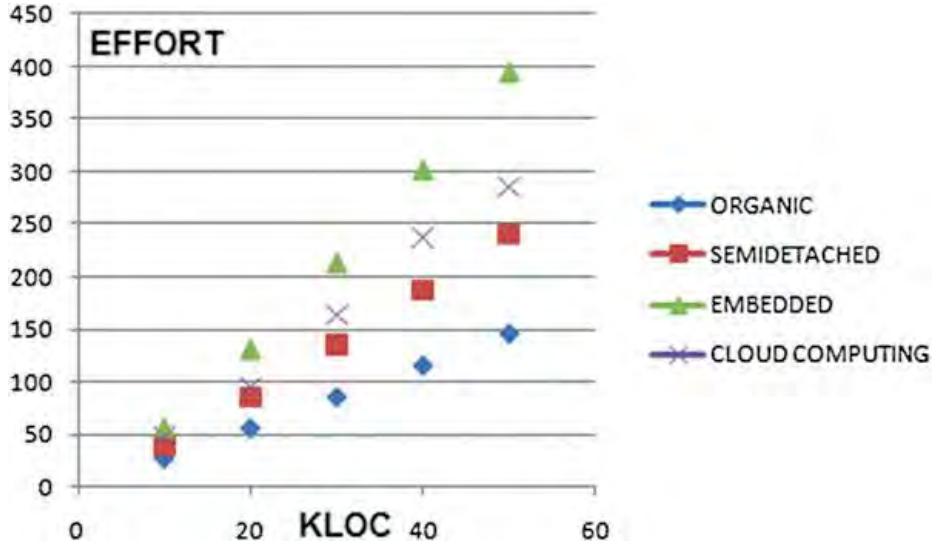
Software proj.	a	b	c	d
Organic	2.4	1.05	2.5	.38
Semidetached	3.0	1.12	2.5	.35
Embedded	3.6	1.2	2.5	.32
Cloud comp.	4	1.2	2.5	.3

$$\text{Effort Applied} = a(\text{KLOC})^b \left[\text{man months}\right]$$

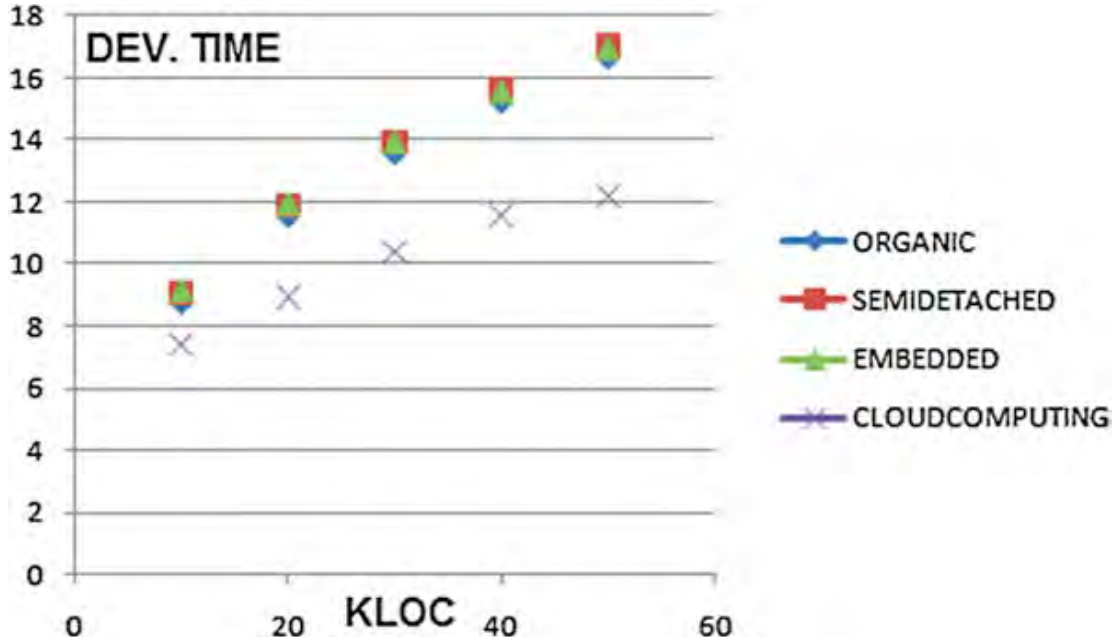
$$\text{Development Time} = c(\text{Effort Applied})^d \left[\text{months}\right]$$

$$\text{No. of People} = \text{Effort Applied} / \text{Development Time}\left[\text{no.}\right]$$

Extended COCOMO for SW effort estimation



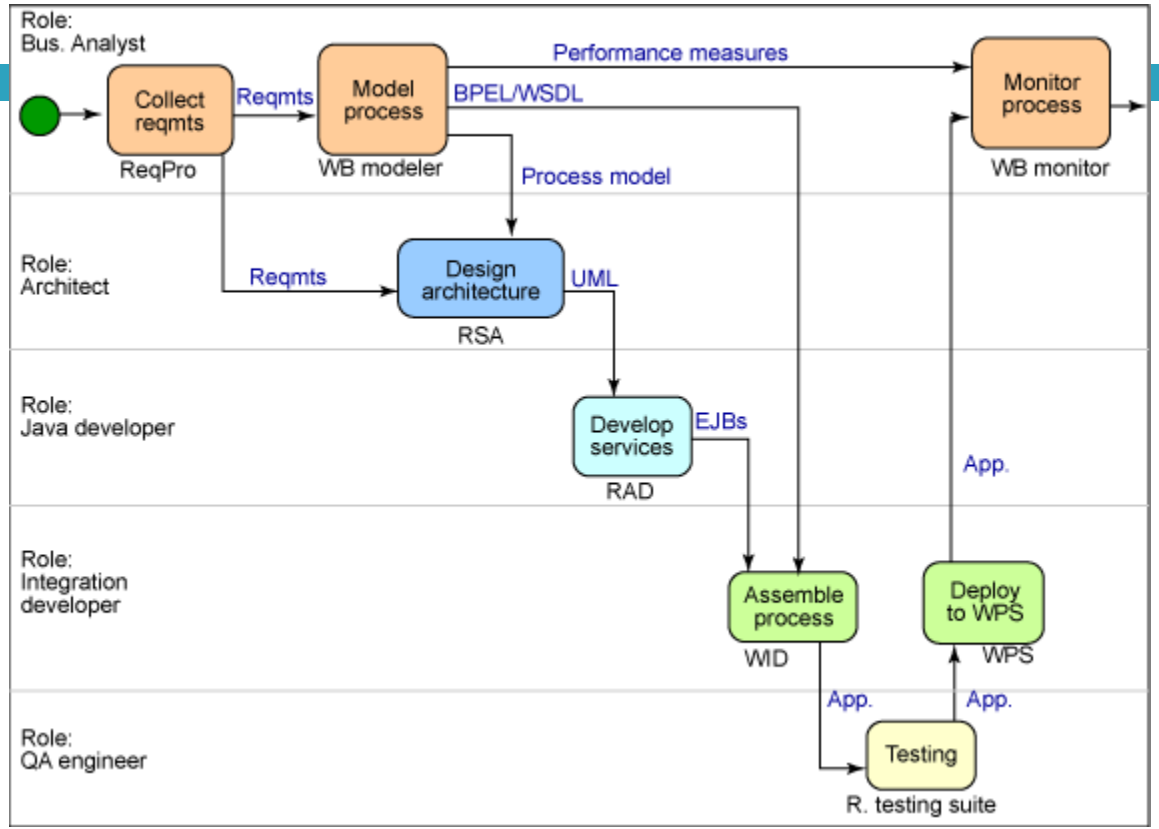
Extended COCOMO for SW dev. time



PART 3: SOA DEVELOPMENT PROCESS & STANDARDS

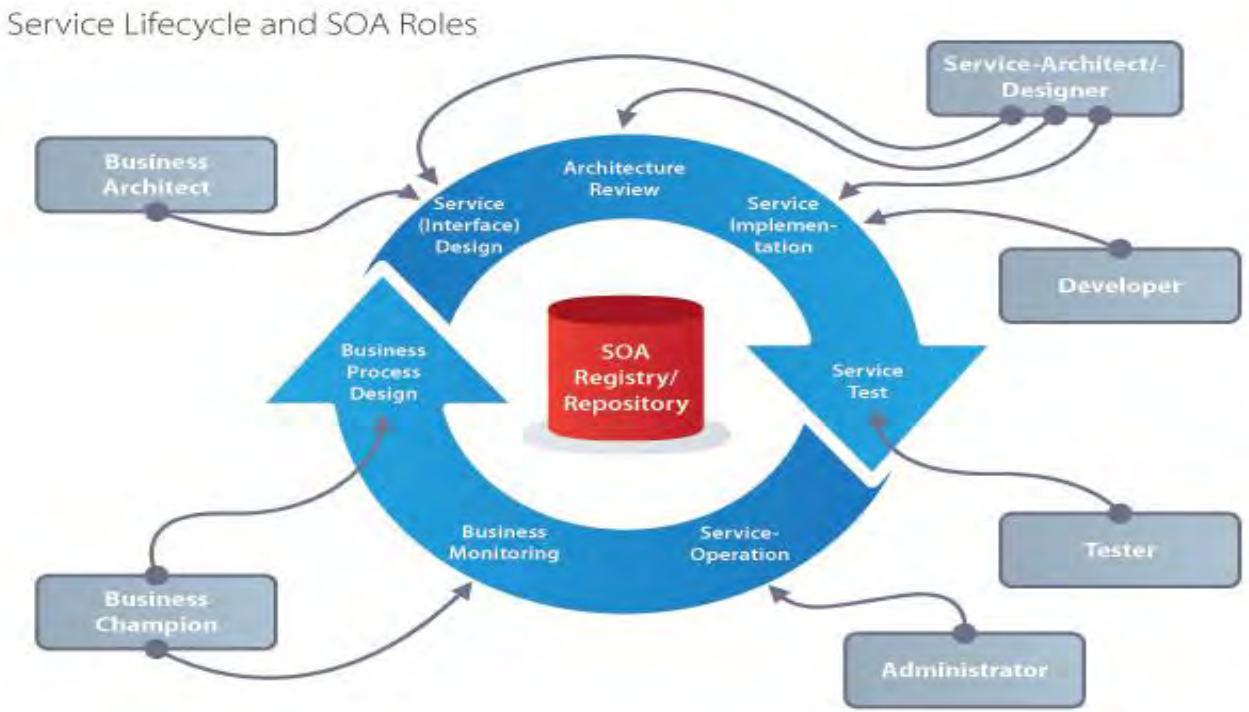
Service Oriented Development Process

- Business Process Identification, Modelling, Simulations
- Service Requirements Engineering & Task Modelling
- Service Design & Architecture (including CBSE)
- Service Implementation , Testing, & Deployment

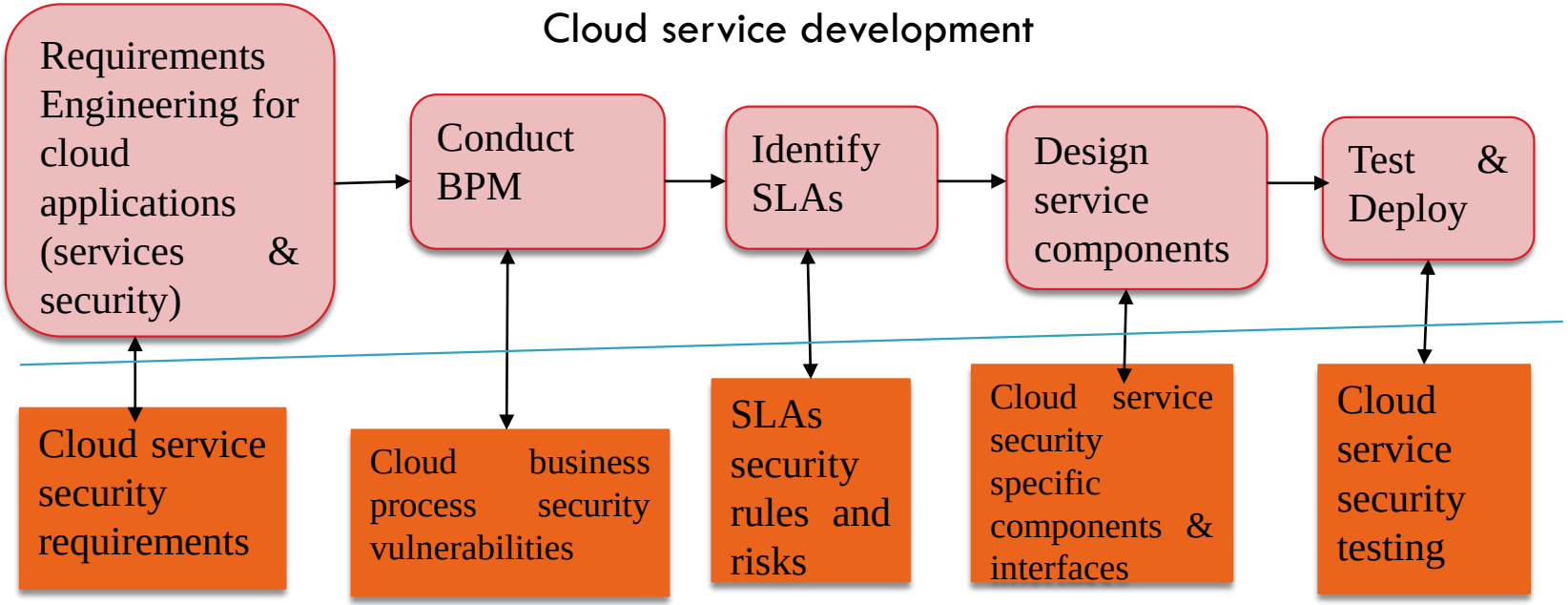


LEEDS BECKETT UNIVERSITY

SOA Lifecycle



Cloud service security development process with build in security – Our Systematic Approach to adopt BSI as part of CCAF



Build Cloud Security In – Cloud service development with build-in security

LEEDS BECKETT UNIVERSITY

Software Engineering for SOA and Cloud Computing

BPMN
- Initial process models: Actors/roles/Workflows
- Detailed workflows
- Service Task modelling
- UI prototyping
- Process Simulation:
  - Configure Resources need for tasks
  - Load profiles in sec/min/days/no.of instances
  - Start the Process Simulation as a Service (PSSaaS)

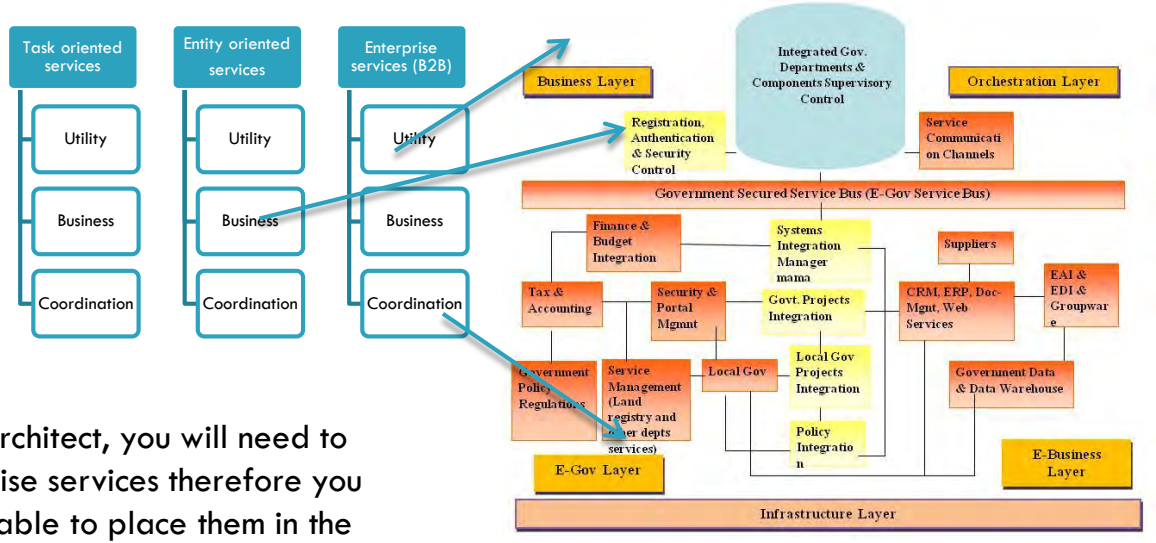
SOA Requirements with use case modelling, story cards, (Agile), Story Boards, CRC Cards, Feature-Oreinted modelling

SOA Design with Service Component Models

SOA Implementation with SOAP/RESTful

SOA Test & Deliver

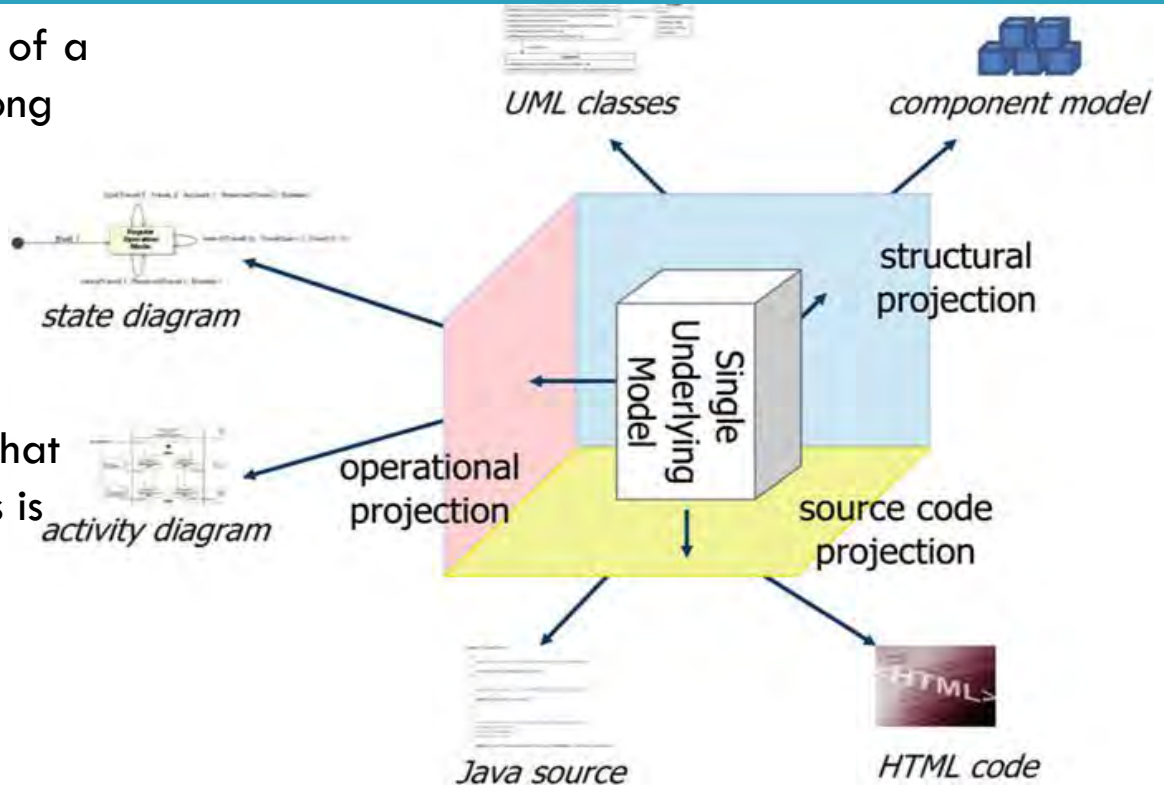
Mapping Services to SOA Design



As an Architect, you will need to categorise services therefore you will be able to place them in the appropriate architecture layers on the right

Orthographic Software Modelling (OSM)

The figure shows three distinct views of a software system being projected along three dimensions, to highlight the analogy with the CAD of physical artifacts. However, in the software space, there is no restriction on the number of dimensions that can be defined and the number of choices that can be made in each dimension. This is based on the multi-dimentional modelling work of korbA.



Invitation Call for Chapters on Exploring Security in Software Architecture and Design, IGI Global

- The proposed book is very essential for establishing secure software design as it is vulnerable to 50% security flaws (refer IEEE secure design guide), https://www.synopsys.com/content/dam/synopsys/sig-assets/whitepapers/top-10-software-security-design-flaws.pdf. Consider following topics but not limited to:
- Best practice security design guidelines
- BSI (build in security design flaws)
- Design for Security
- Architectural security analysis
- Architecture security risk analysis (ARA)
- Security testing of software and systems architecture,
- Architecture security evaluation, validation, and verification, etc.
- SOA security
- Enterprise Architecture Security
- Cloud Architecture Security
- The book is published by IGI Global and submit your chapter by 15th September 2017.
- AUTHOR'S GUIDE TO PREPARING CHAPTERS (http://www.igi-global.com/publish/contributor-resources/before-you-write/
- AUTHOR'S CHAPTER SUBMISSION CHECKLIST (http://www.igi-global.com/publish/contributor-resources/edited-book-author-checklist/
- Please submit your enhanced article in Microsoft Word Format with the word "Enhanced" in the file name through the eEditorial Discovery® system by no later than 15th September 2017. Please use the following link when submitting your enhanced article:
- https://www.igi-global.com/submission/?returnurl=%2fsubmission%2fbooks%2f

Research collaborations will enhance our community of EA Research Activities.

LEEDS BECKETT UNIVERSITY

Conclusion & Questions

- The SOA success factors can be summarized as follows:
- Service computing is the future
- Systematic approach to developing services can avoid disasters
- We can learn from mistakes of the past

References/Reading List

- Erl, T (2005) SOA: concepts, technology, design, Prentice Hall/Pearson Education
- Erl, T (2004) Service-Oriented Architecture: A Field Guide to Integrating XML and Web Services
- **Erl, T et al. (2015) Next Generation SOA, Prentice Hall**
- Krafziq, D, et al. (2004) Enterprise SOA: Service-Oriented Architecture Best Practices, Prentice Hall/Pearson Education
- Elfatatry, A (2007) Dealing with change: components versus services, COMMUNICATIONS OF THE ACM August 2007/Vol. 50, No. 8
- Papazoglou, P. M. et al (2007) Service-oriented computing: state of the art and research challenges, Special Issue on Service-oriented Computing, IEEE Computer, V.40, No.11, November 2007
- Yang, J (2003) Web service componentisation, CACM, October Vol 46/N 10
- Ramachandran, M (2008) Software Components: Guidelines and Applications, Nova Science Publishers, New York, USA. ISBN: 978-1-60456-870-7, October/November 2008, https://www.novapublishers.com/catalog/product_info.php?products_id=7577 Pages 410
- Ramachandran, M (2011) Software Security Engineering: Design and Applications, Nova Science Publishers, New York, USA, 2011. **ISBN:** 978-1-61470-128-6, https://www.novapublishers.com/catalog/product_info.php?products_id=26331
- Ramachandran, M (Editor) (2011) Knowledge Engineering for Software Development Life Cycles: Support Technologies and Applications, IGI Global Publishers, **ISBN-13** 978-1609605094, USA, **http://www.igi-global.com/bookstore/titledetails.aspx?titleid=46170**
- Ramachandran, M (2011) Software components for cloud computing architectures and applications, Springer, Mahmmood, Z and Hill, R (eds.).

LEEDS BECKETT UNIVERSITY