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Research Roadmap for Service Oriented Computing

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OUTLINE

- ✧ Overview, Vision & Aim
- ✧ Example: Smart Services
- ✧ Services & SOA
- ✧ Services in the Cloud
- ✧ Research Roadmap
- ✧ Final Remarks

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TALK OBJECTIVES

- Overall Objective:
  - Understand the forces behind Service Oriented Computing
  - Understand the nexus between SOA, BPM & the Cloud
  - Present a Service Oriented Computing Research Roadmap
  - Place on-going research activities and projects in the broader context of this roadmap.
- Basic understanding of Web services, standards & SOA is assumed.

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Overview, Vision & Aim

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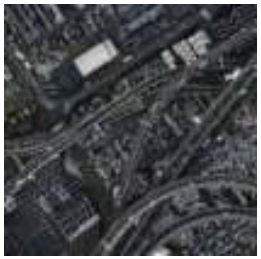
Smart Applications

The world needs to get smarter – more instrumented, interconnected & lead to better decision making.
Smarter Service & Cloud technologies are central to this vision.

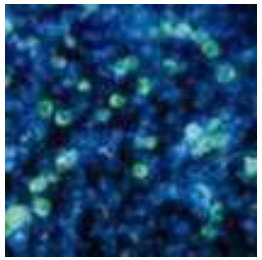

Smart traffic systems


Smart business systems


Smart food systems


Smart healthcare

(Process-intensive & event-driven apps)


Smart water management


Smart supply chains


Smart telephony


Smart cities

Global-reach *agile* service-based apps are effectively deployed into a variety of devices & different implementation platforms - in particular federated cloud computing formations.

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Smart Services & SOA

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What are Smart Services?

- Smart services are a new breed of cloud services that are self-describing entities that carry with them capability, contextual awareness (e.g., wrt time, location & preferences) & resource capacity information, & span multiple service providers' physical environments (both private & public).

- Smart services:
  - are modular, shared, standard & easily integratable with little effort with other such services into "value propositions".
    - They simplify programming enabling user-generated services.
  - improve decision making.
  - create a flexible services-oriented environment for agencies where apps, e.g., health, urban, or environmental, can tune themselves to achieve optimal resource consumption to yield higher levels of innovation & productivity.
  - offer rapid provisioning and deployment of services & on demand scalability & elasticity for services & capabilities while maintaining health performance levels.

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Smart Services & SOA

- Central to the smart services challenge is the concept of Service-Oriented-Architecture (or SOA).
- SOA is a design philosophy "the software equivalent of Lego bricks" where a collection of mix-&-match units (called "services") can reside on geographically dispersed machines possibly under the control of a different service provider & are ready to be used whenever needed.
- A software service:
  - accomplishes a specific business task, e.g., gather real-time traffic info. or suggest less-congested routes to drivers, or
  - may compose several software services to create a value-added distributed service-based app, e.g., integrated traffic networks that allow people to make connections easily and take the fastest route using multiple modes of transport.

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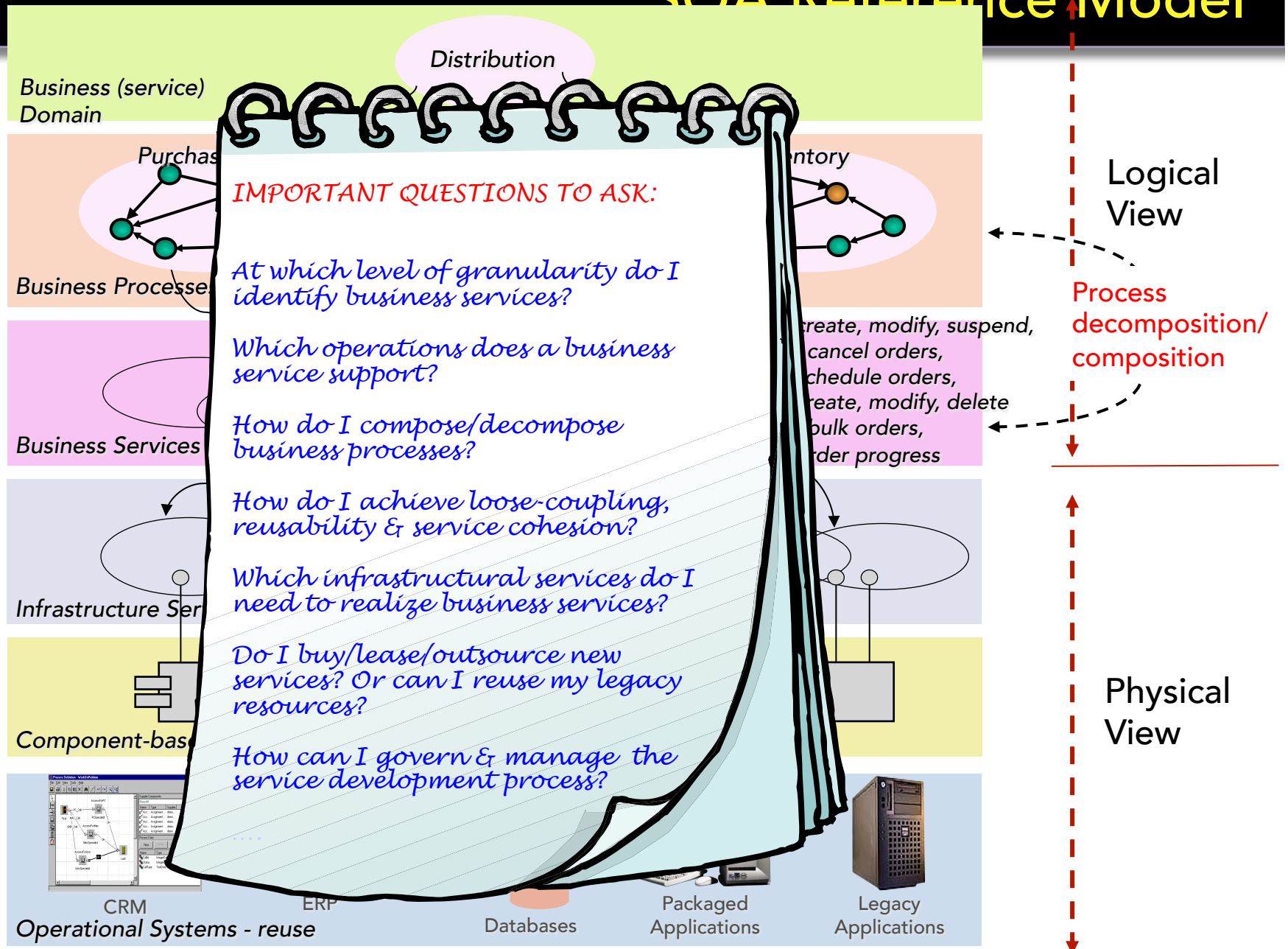
SOA Reference Model



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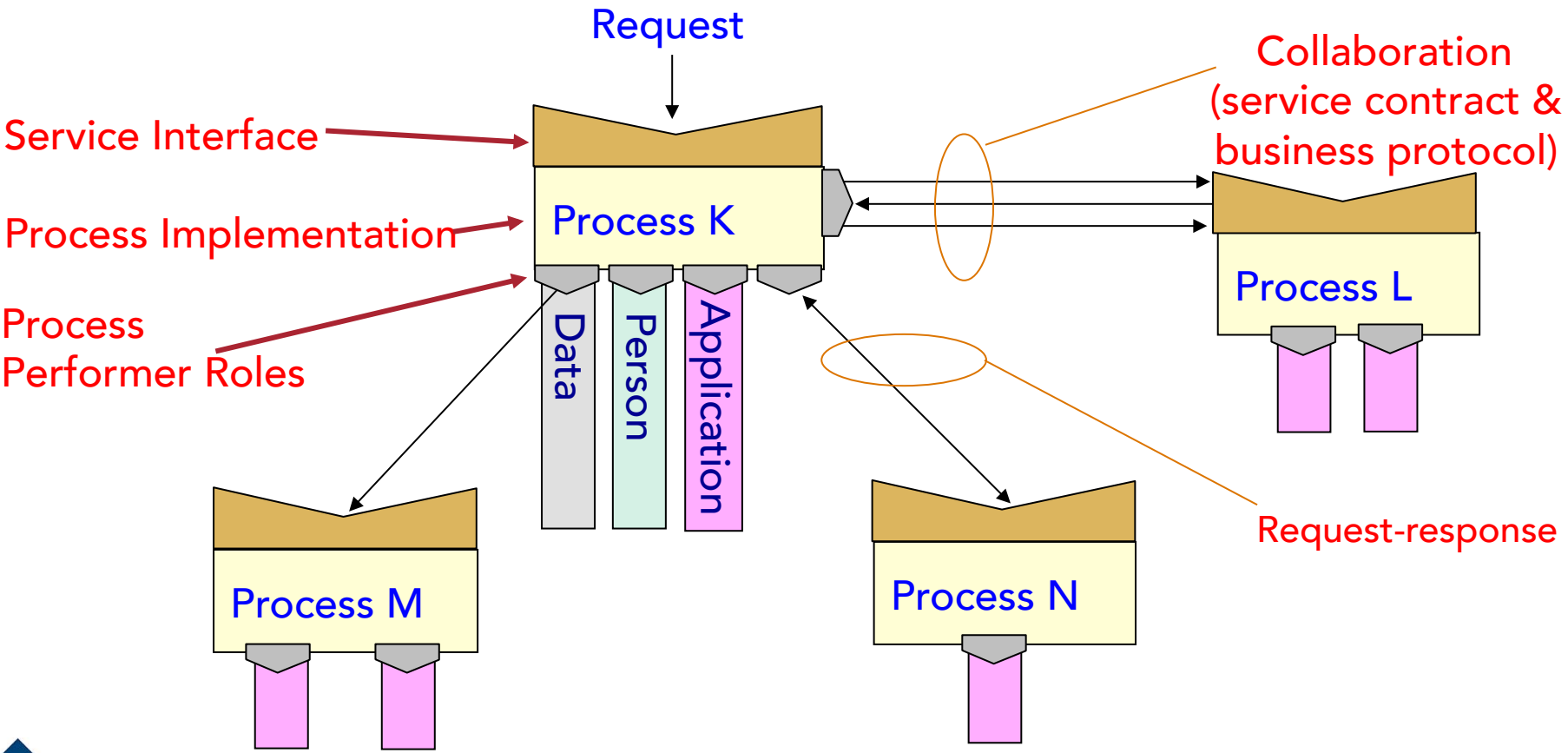
Business Processes as Services

Focus concentrates on Business Processes

- The Business Process as Service
- The Business Process as a Catalyst for Collaboration



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Services in the Cloud

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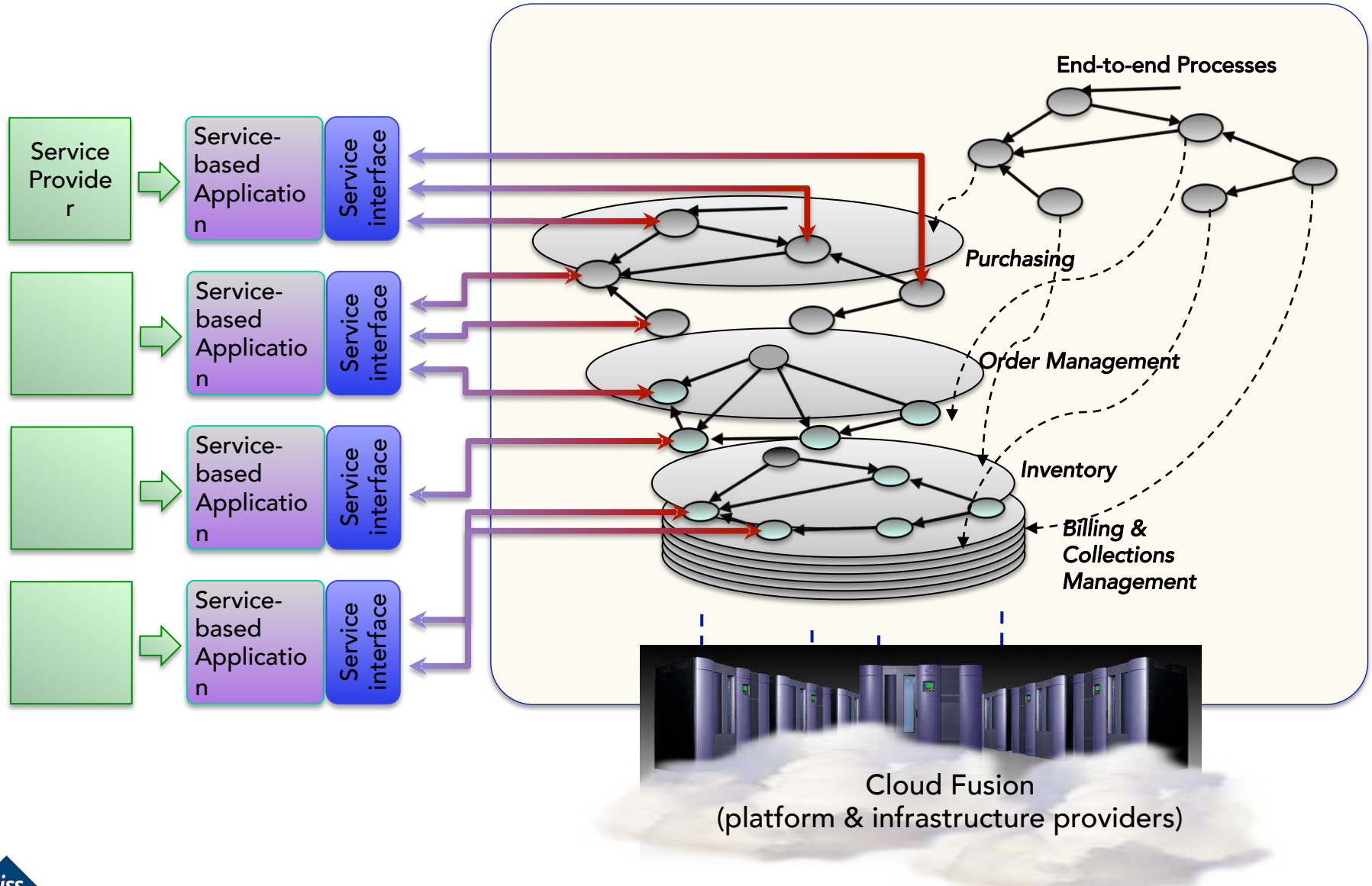
SOA in the Cloud



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Cloud Overview

Cloud: Consumption & Delivery Models Optimized by Workload

"Cloud" is:

- A new consumption and delivery model inspired by consumer Internet services.

Cloud enables:

- Infrastructure configuring
- Highly virtualized infrastructure
- Sourcing options
- Economies-of-scale

"Cloud" represents:

- The Industrialization of Delivery for IT supported Services

Multiple Types of Clouds will co-exist:

- Private, Public and Hybrid
- Workload and/or Programming Model Specific

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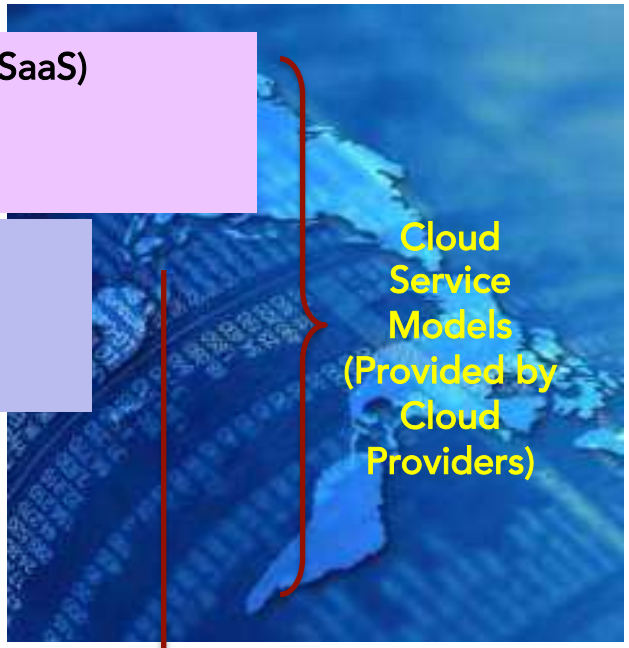
Cloud Computing & Delivery Models

Cloud Applications (Built by customer)

Software as a Service (SaaS)
- Applications (ERP, SCM, CRM)
- Processes
- Information

Platform as a Service (PaaS)
- Middleware – application servers,
- Process automation middleware,
- Database servers,
- Enterprise portal servers, etc.

Infrastructure as a Service (IaaS)
- Virtualized servers,
- Storage,
- Networking



Cloud Deployment Models

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Research Roadmap

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Research Challenge: Smart Service Networks

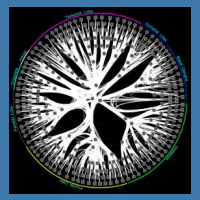
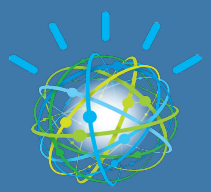
Smart Service Networks Era

Far-reaching research

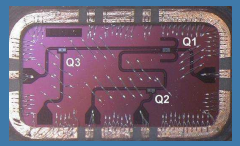
Smart Applications

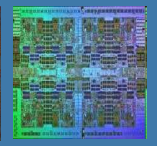
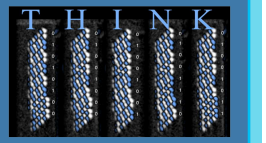


Architectures


Core Technologies



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Some Long-term Open Research Problems

- Smart service networks are globally dispersed, could be created on-demand & are characterized by:
  - Federated Cloud Environments
  - Openness
  - Agility
  - Scalability
  - Uncertain (non-deterministic) processes
  - Evolvability & adaptability
    - Adaptable infrastructure where hardware is optimized and packaged as an appliance (IaaS)
  - Demand rather than supply driven processes: business process activity driven by actual customer demand
  - Combining big-data, associated processes & big-analytics - prediction:
    - sensor networks, social networks, social data analysis, …
  - Support for a change-oriented lifecycle
  - Innovation, i.e., support for innovative & emerging business models
  - User empowerment

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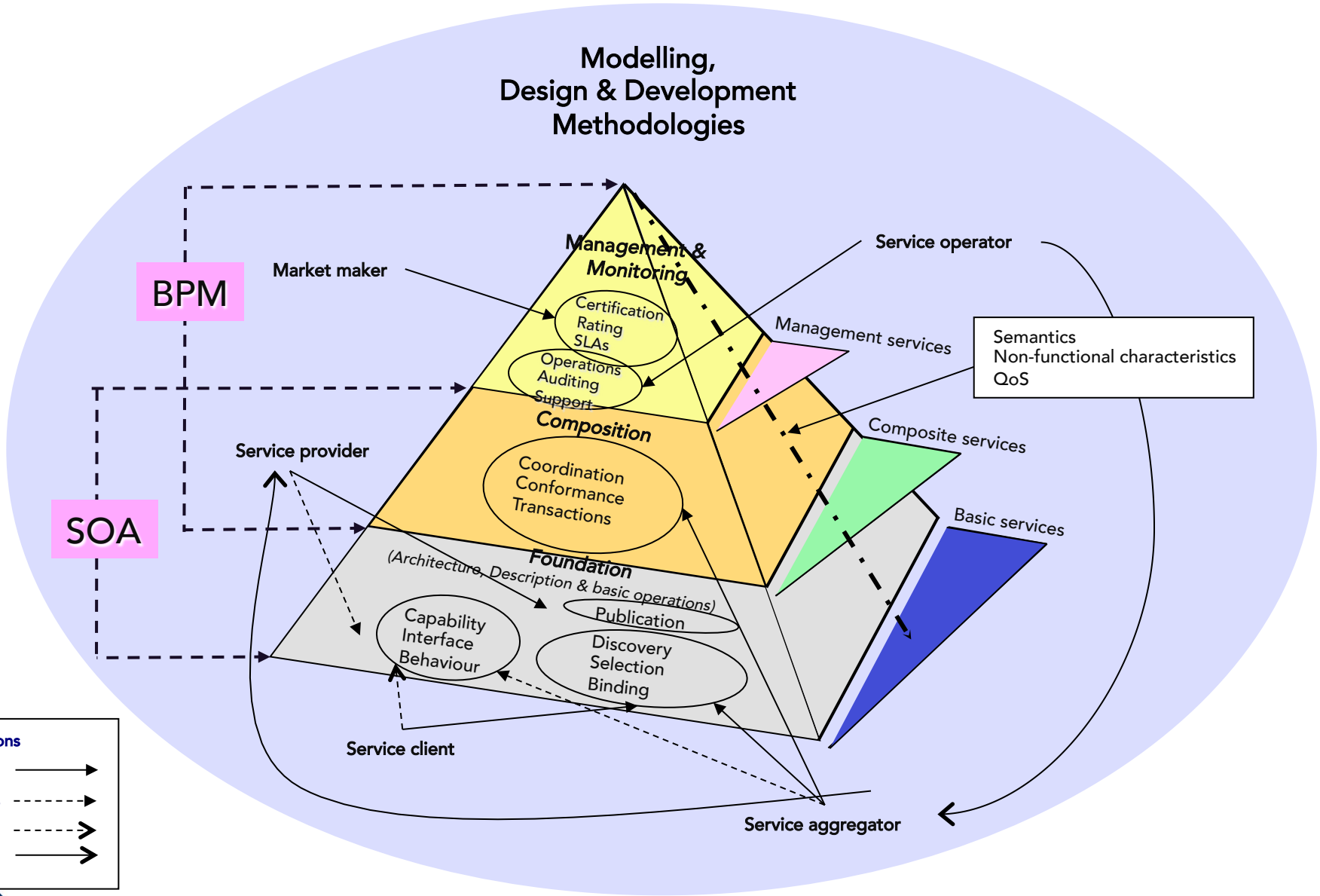
Extended SOA (xSOA)



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Summary of Research Themes

- Service Foundations: adaptable infrastructures & runtime architectures employing diverse modes of service delivery, e.g., mobile devices, palm tops, hand held devices, sensor networks, RFID, etc. (Internet of Things)
- Service Composition/Assemblies: service composition, QoS composition, SLA composition, data composition, etc.
- Service Management: support for discovering, introspecting, securing, and invoking resources, management functions, measurement, performance indicators, management infrastructure services and toolsets.
- Service Development Life Cycle (Service Engineering): service analysis, design methodologies, implementation techniques, construction and testing, provisioning, deployment, execution and monitoring, business process modelling tools.
- Cross-cutting concerns: QoS, semantics, non-functional characteristics, security, privacy, policies …

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Service Foundations: Typical Research Challenges

- Requirements for the service implementation infrastructure:
  - is the cloud model appropriate for SOC?
  - provisioning mechanisms, e.g., end-to-end security, transactions, etc.
  - composition of associated processes, data, QoS & policies
- Dynamically (re-)configurable run-time architectures:
  - The run-time service infrastructure should be able to configure itself and be optimized automatically in accordance with specific application requirements & high-level policies (representing business-level objectives)
  - Plug-in Architecture to deal with extensible sets of functional & QoS properties:
    - **How do we deal with: end-to-end security solutions, multiple SLAs, business-aware transactions, flexible pricing schemes, etc.**
- Demand-driven creation & evolution of smart service networks.

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Service Composition: State of the Art

- Research activities have mainly concentrated on:
  - dynamic compositions
  - modularizing/parameterizing compositions
  - analysis of Business Processes & Protocols
  - providing context aware services to enable compositions
  - AI planning techniques to automate the retrieval and composition of Web services.

- Lack of support for the evolution, adaptation & versioning of business processes.

- Lack of associating vital data & constraints - with business processes that may even trigger business transactions.

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Service Composition: Typical Research Challenges

- Composability analysis for replaceability, compatibility, and conformance for dynamic and adaptive processes.
- Adaptive and emergent service compositions, e.g., via the use of declarative service request languages.
- QoS-aware service compositions that understand & respect each other's policies, performance levels, security reqs & SLA stipulations
- Autonomic composition of services:
  - Self-configuring compositions e.g., composite services capable of automatically discovering new partners to interact with or can choose among different options available.
  - Self-optimizing service compositions that automatically select the best possible partners and options to maximize benefits and reduce costs.
  - Self-healing compositions that automatically detect that some business composition requirements are no longer satisfied by the implementation & react to requirement violations.
  - Self-adapting service compositions that function in spite of changes in behaviours of external composite services for adapting services to subsequent evolutions.

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Examples from a Medical Cloud

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Medical Cloud: A Better Integrated Medical World

Better access to integrated care designed around the patient with a greater focus on early intervention & provision of care

Point of care (for patient & provider)

- Aggregation of clinical information across hospitals & providers
  - ✧ Immunization history
  - ✧ Individualized medication lists
  - ✧ Allergies, laboratory, radiology, procedures, EKG
- Decision support for clinical guidelines

Clinical messaging (provider to provider)

- Laboratory test orders/results exchange
- e-Prescribing
- Case reporting, electronic laboratory reporting
- Ancillary/referral service results (e.g., radiology, consultant reports)

- Connected Doctors
- Connected Patients
- Connected Hospitals
- Connected Medical Diagnosis Devices
- Connected Patient Embedded Devices
- Connected Laboratories
- Connected Medical Home
- Connected Health Information Systems

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Interacting Smart Medical Devices

SMARTNESS IS:
Gaining real-time line of sight, optimizing use of resources & planning a coordinated response to individualized health needs.

Set-up & organization of devices & infrastructure in the form of smart services

Smart labels & tags

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Example: Personalized Healthcare

Personalized Healthcare:
A shift towards proactive, predictive medicine

Smart Patient-Centric Healthcare

- The smarter approach to healthcare turns medical data & processes into clinical & business insights for better outcomes.
- Provides a more efficient way to store, distribute, share & integrate medical data, documents & digital images & makes the information more accessible to the full range of healthcare providers.
- Healthcare will become more personalized with greater patient-empowerment
    - Mobile Healthcare and Wearable Sensors
    - Intelligent Personal Assistants

Integrated Medical Services

- Smarter healthcare cloud applications can seamlessly deliver a globally integrated healthcare infrastructure & integrated care centred on the patient.

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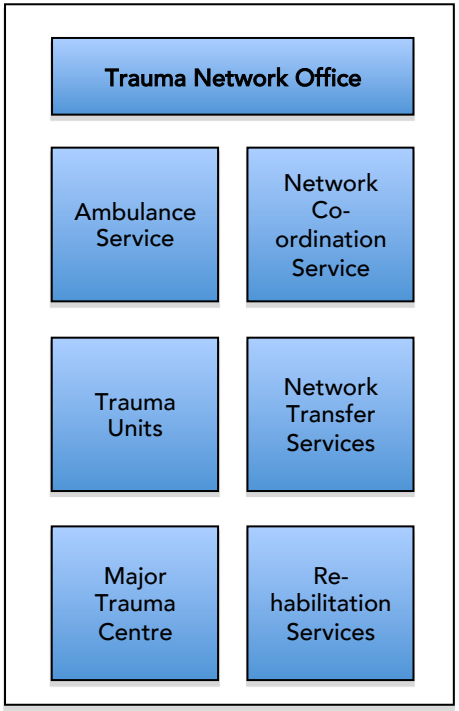
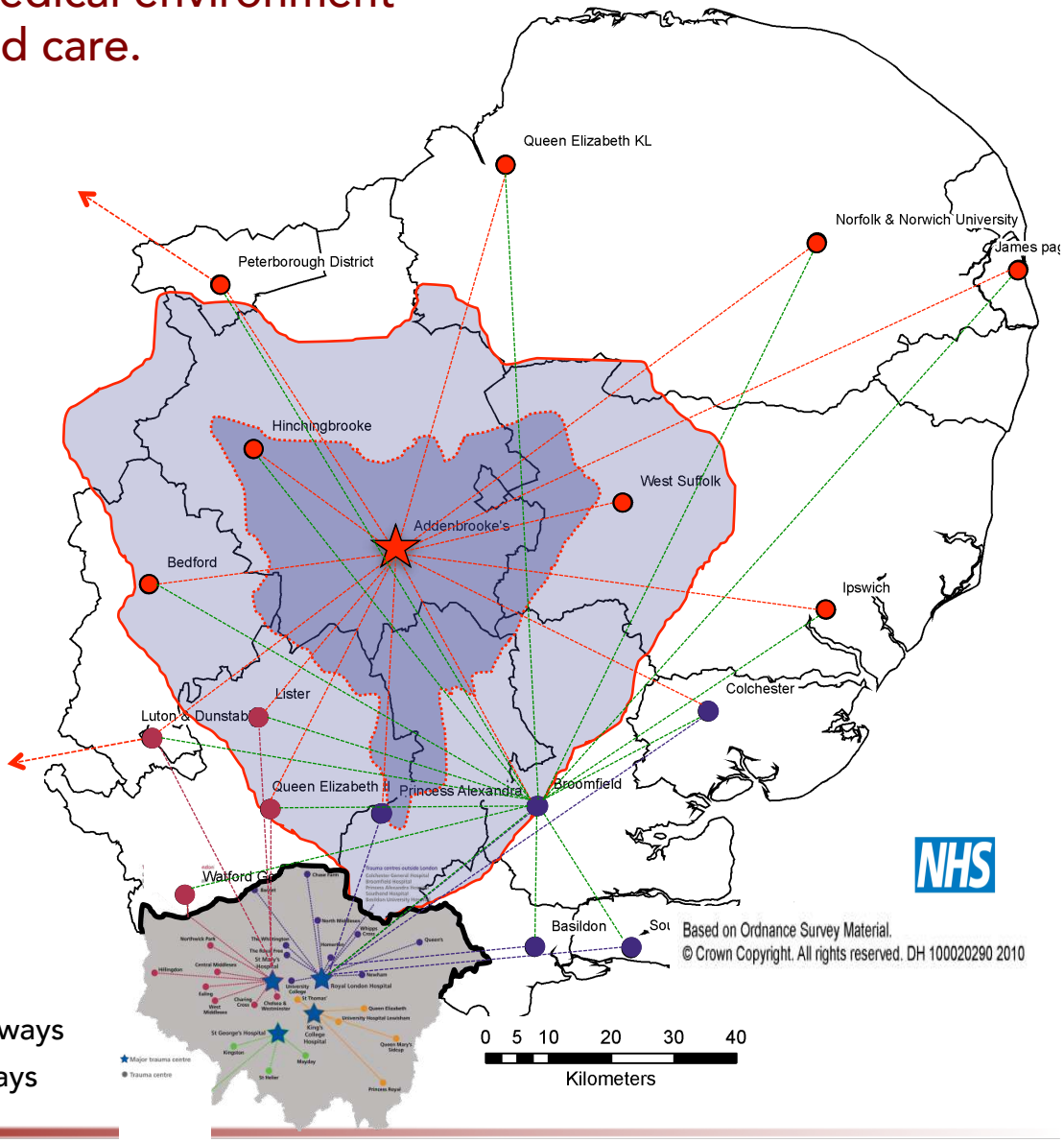
East of England Smart Management Cloud

Provides access to an integrated medical environment that helps deliver more personalised care.





- Hospital Type 1 Emergency Dept.
- Major Trauma Centre
- Primary (peak and off –peak 45 minute) transfer zone*
- Burns Centre secondary transfer pathways
- Brain injury secondary transfer pathways

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Features of the Medical Blueprint Model

- BUSINESS LEVEL:
  - Better coordinates and personalizes care by providing other health care providers access to comprehensive and longitudinal medical records, and providing individuals access to their own records through personal health records.
- INFRASTRUCTURE-(CLOUD)-LEVEL:
  - It lets developers syndicate, configure, partition & deploy virtual app solutions comprising smart services on resource pools in the cloud by clearly separating service processing concerns.
  - It uses a model-driven approach to map declarative configuration points for abstract cloud service specifications to available resources, & composes them into complete solution models (using simple aggregation & cross-configuration of virtual services) taking into account technical features & workloads.

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Shared Medical Context: 5x5 Medical Model

Five Medical Resource Object Models

Stakeholders	Patient type, personnel & partner resources for cure
Patient Care Devices & Equipment	Equipment/resources managed for cure
Medical Record & Tests	Medical Record, & patient tests
Medication	Medication need for treatment
Medical Process Segments	View of medical flow processes

Capacity, Schedule, Flow, Safety & Performance

Capacity	What is available for use for cure
Patient Symptoms – Cure	What is needed to cure a patient
Safety Procedures	Safety regulations & procedures, clinical practices rules
Medical Schedule & Workflow	Coordinated care: What to cure & resources to use & when
Treatment Performance	What was treated, what was achieved & resources actually used

TECHNICAL REQUIREMENTS

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Stakeholders Blueprint

Stakeholders (Actors) - Blueprint

A. Healthcare Provider

- Healthcare Facility
- Clinician (Primary Care Provider, Specialist, etc)
- Nurse (Specimen Collector)
- Clerk (Administrative Staff)

B. Laboratory Provider - Staff

- Laboratory (Contract Laboratory, Hospital Laboratory, etc.).
- Laboratory Technician
- Laboratory Data Manager

C. Public Health Staff

- Public Health Diabetes Care Management/ Control Program
- Program Staff (Data Manager, Case Manager, etc.)

D. Patient (Consumer)

- Type 2 Diabetes Patient

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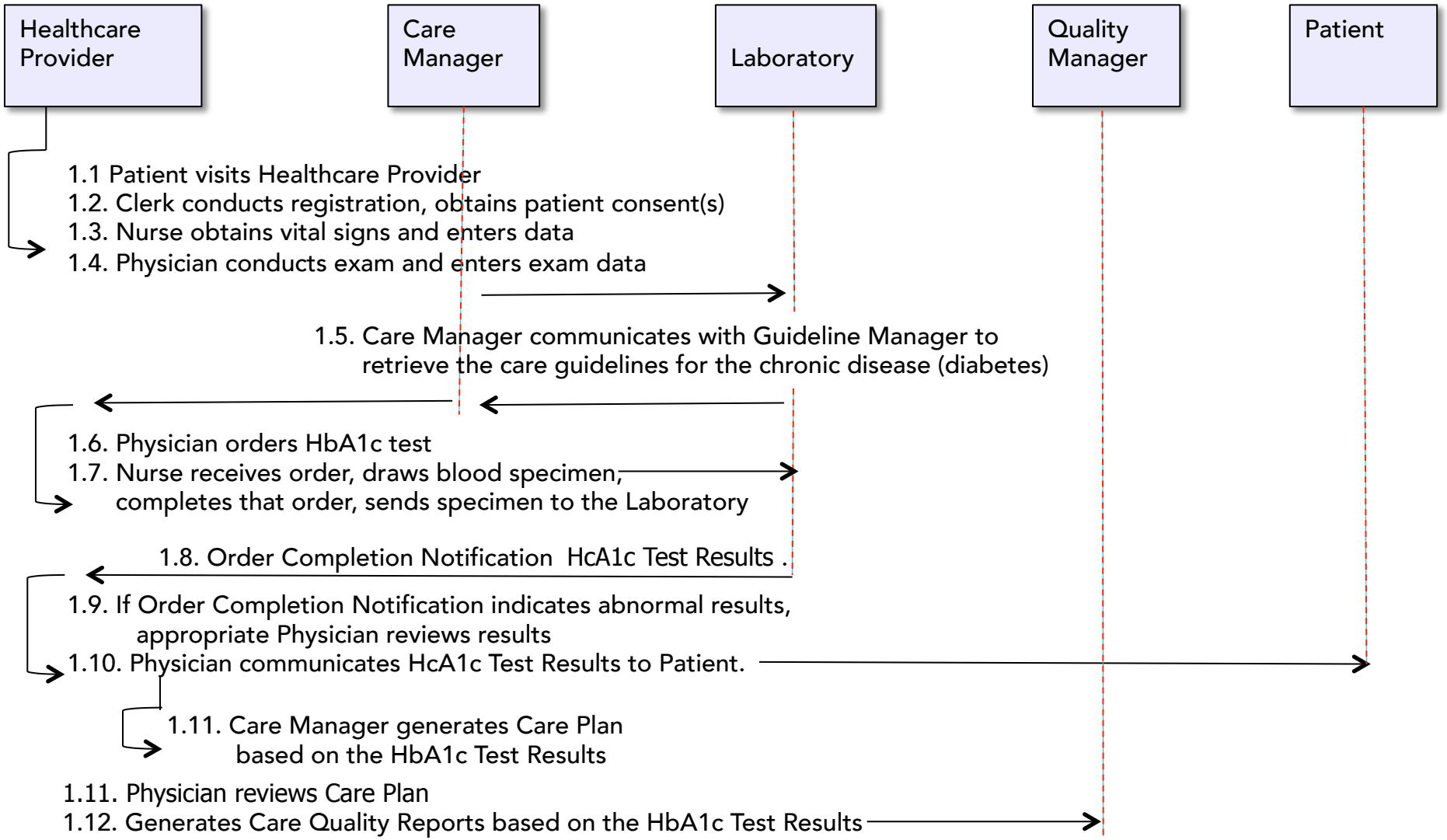
Chronic Care Schedule & Workflow Blueprint



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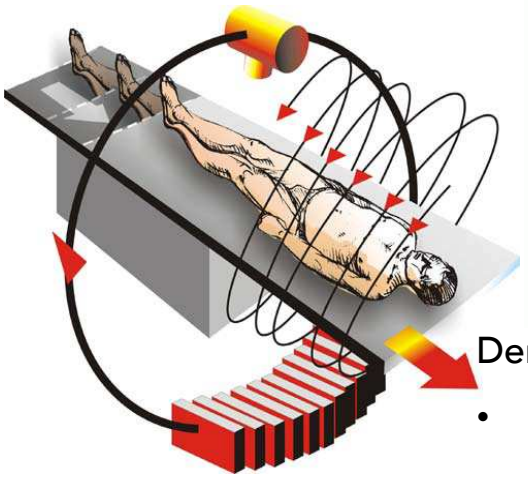
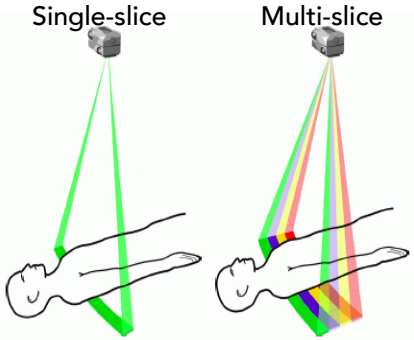
IaaS Requirements: Critical Healthcare Apps

MRI files ~100MB (raw)
Multi-slice cardiac files > 500MB
Radiology studies create 50 – 100 MB
Pathology studies 1-10 GB

Memory Requirements

Network requirements: High-speed & reliable transport





Density of imaging capabilities:

- ~320 slice images

Real-time delivery of modalities required

IaaS Technical – Blueprint

CPU Requirements, Memory Requirements

……

Network Requirements:

High-speed optical network:

- Inter-site bandwidth
- Total built capacity
- Scalability
- Flexibility & turn-around time for growth

24x7 availability:

- Fiber links are protected at the 7x50 to ensure connection to a peer is maintained thru alternate paths in case of a single fiber cut.
- In the case of a fiber cut, the data connectivity is restored within 50ms via MPLS fast re-route.

Site-to site connectivity options:

- Virtual Private Routed Network (VPRN)
- Virtual Private LAN Services (VPLS)
- e-Pipe Networking, etc

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Technical Requirements: Standards

1. Data Standards (vocabularies and terminologies):
   - (e.g., Clinical terminology (SNOMED), laboratory data (LOINC), administrative data (ASC X12), etc).
2. Information Standards:
   - Interoperability reference models, e.g., Integrating the Healthcare Enterprise (IHE)
3. Information Exchange Standards (message-based and structured document-based to support patients' health & care needs):
   - Health Level Seven (HL7) – defines information exchange standards
4. Identifier Standards:
   - (e.g., National Provider Identifier (NPI)-40)
5. Privacy and Security Standards
   - (e.g., access control, audit, electronic consent - HIPAA Privacy Rule and Health)
6. Functional Standards
   - (e.g., work processes, workflow and dataflow models)
7. Other Standards
   - (e.g., Internet standards, etc.)

Technical requirements are distilled in technical blueprints (not shown)

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Closing Remarks

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Summary

- Research activities in SOC are very fragmented. This necessitates that a broader vision and perspective be established—one that permeates and transforms the fundamental requirements of complex applications that require the use of the SOC paradigm.
- We discern three driving forces: SOA, BPM & the Cloud
- The SOC research roadmap launches four pivotal, inherently related, research themes to SOC:
  - service foundations,
  - service composition,
  - service management and monitoring, and
  - service-oriented engineering.

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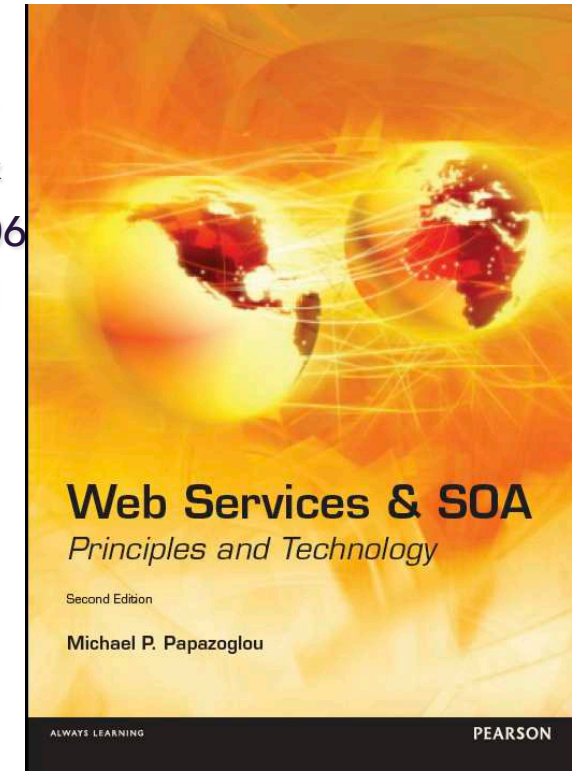

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