Semantic Technology in Business Systems
Status & Prospects

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IT Research Centre, BT

Next Generation Web team

- BT Research

- Longstanding interest in semantic technology and its application

  – OntoKnowledge (1999)

  – Semantic Web-enabled Web Services (SWWS) (2001)

  – More recently, ACTIVE and SOA4All projects; many internal projects

- Increasingly also looking at Web 2.0 and its relationship with Semantic Technology

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Overview

- **Brief introduction to semantic technology**

- Applications
  - Knowledge Management
  - Information Integration
  - Service-oriented environments
  - Business Intelligence
  - ICT Solution Design with Semantic MediaWiki

- Specific application in the health sector

- Semantic Technology uptake

Today's Web is…

- A place where
  - computers do the presentation (easy) and
  - people do the linking and interpreting (hard).

- *Why not get computers to do more of the hard work?*

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Semantic Web

- ## Today's web
  - Machine-to-human – emphasis on presentation

- ## Semantic web vision
  - "an **extension** of the current web in which **information** is given well-defined **meaning**" (Tim Berners-Lee)
  - making web-based information **machine-processable**
  - <bold>**use bold font**</> → <product-code>1234-6/A</> (XML)
  - beyond XML - RDF, OWL ⇨
    - ontological languages
   - formal, supporting reasoning

Ontologies

- An ontology describes a formal specification of a certain domain:
    - Shared understanding of a domain of interest
    - Formal and machine processable

    (telecoms systems, gene structures, public services, ...)

- The notion of ontology is central to semantic web

- W3C has developed standards for describing web-based ontologies
    - Logic-based languages RDF and OWL
    - Specify ontologies and link them to information such as (parts of) web pages, web services, grid resource descriptions, process descriptions, …

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Ontologies & Taxonomies

Taxonomy is a classification system where each node has only one parent and the single relationship between concepts is "ako" – simple ontology

Living Beings

- Animals
  - Vertebrates
  - Invertebrates
- Plants
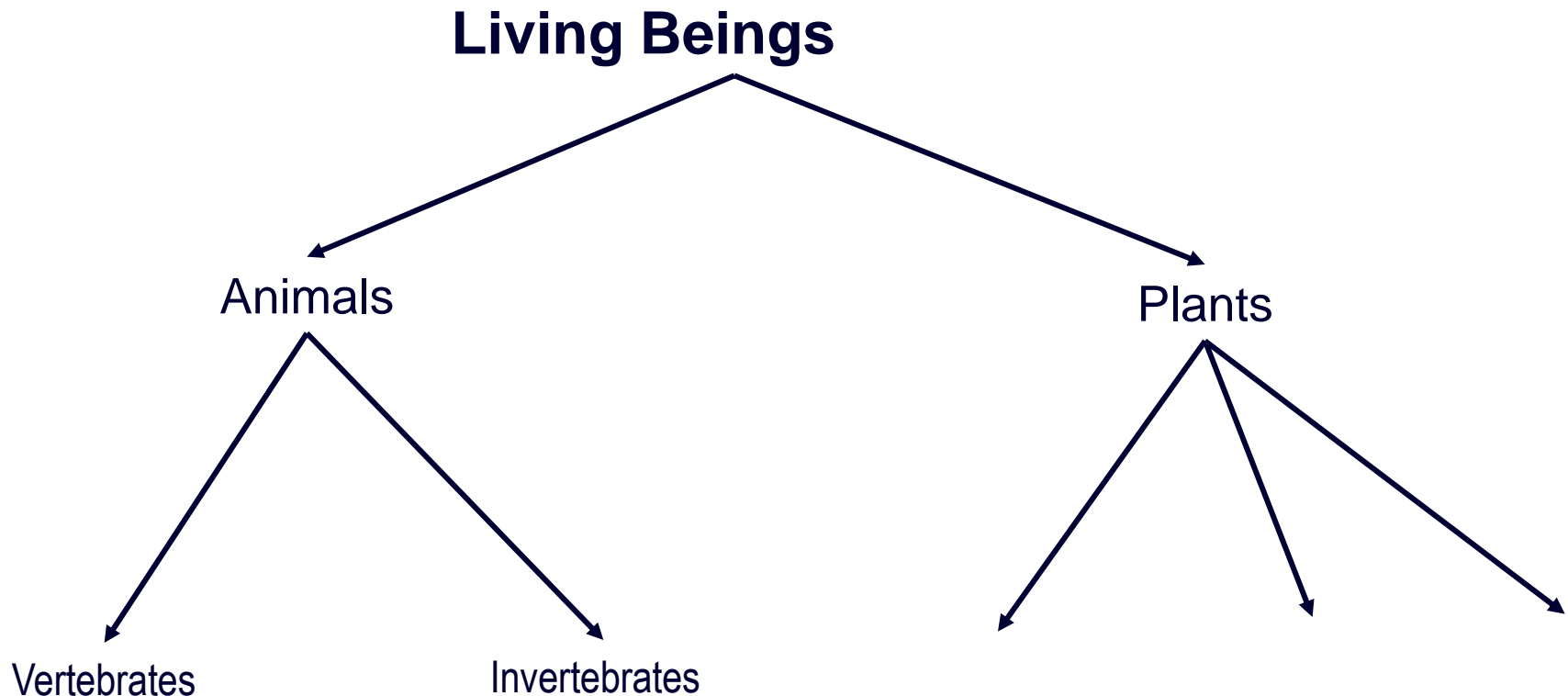
Ontology of People and their Roles
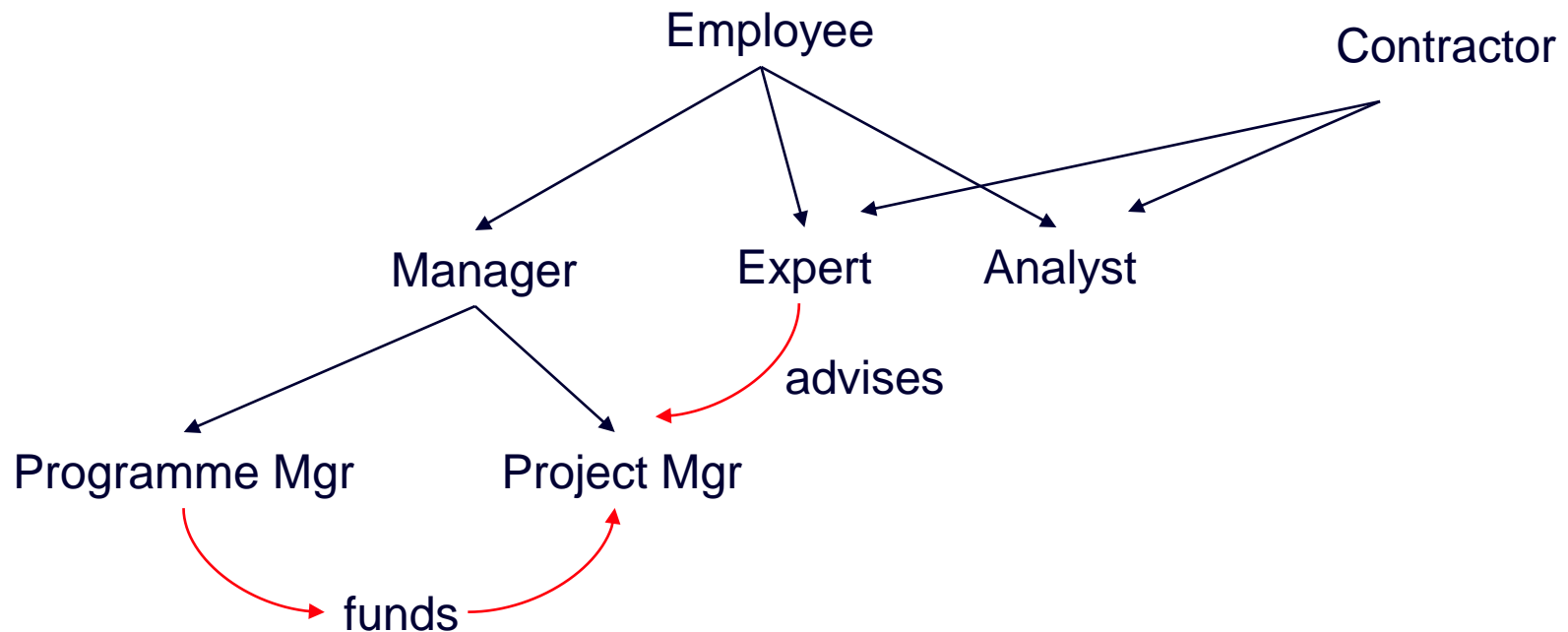
Typically, we want a richer representation with more relationships between concepts: an ontology

Why develop an ontology?

- ***To define information (e.g. web-based) more precisely and make it more amenable to machine processing***
  - by linking data to a formal ontology

- To make domain assumptions explicit
  - Easier to change domain assumptions
  - Easier to understand and update legacy data

- To separate domain knowledge from operational knowledge
  - Re-use domain and operational knowledge separately

- To share a consistent understanding of what information means

- To allow reasoning about data

Ontologies and Description Logic

- Reasoning over ontologies
- Inferencing capabilities

  X co-wrote D; Y co-wrote D ⇨

  　　　X and Y collaborate

  Allergy(X) & triggered_by(almonds, X) ⇨

  　Nut-allergy(X)

  Supplies(X,Y) & Supplies (Y,Z) ⇨

  　Supply-chain-partners(X,Z)

Semantic Web/Semantic Technology

- Ontological languages (the layer cake)
  - XML, RDF, OWL, Rules

- Ontology management techniques and tools

- Metadata extraction tools ('text analytics')
  - Computational linguistics
  - Knowledge discovery/text mining

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In three words

Semantic knowledge management classifies, finds, distributes, shares and uses knowledge based on meaning not the particular words used to represent meaning.

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In three words

Semantic knowledge management classifies, finds, distributes, shares and uses knowledge based on meaning not the particular words used to represent meaning.

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Words and meanings

- same word, different meanings   Jaguar
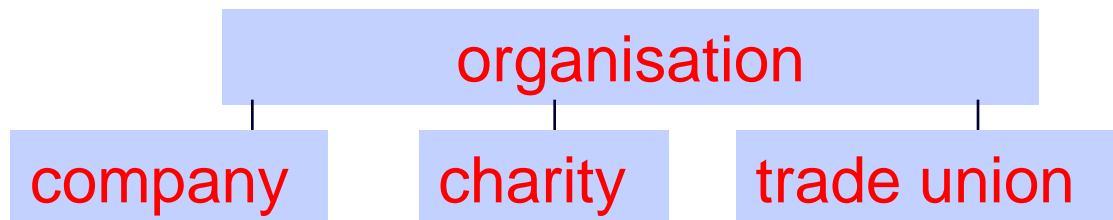
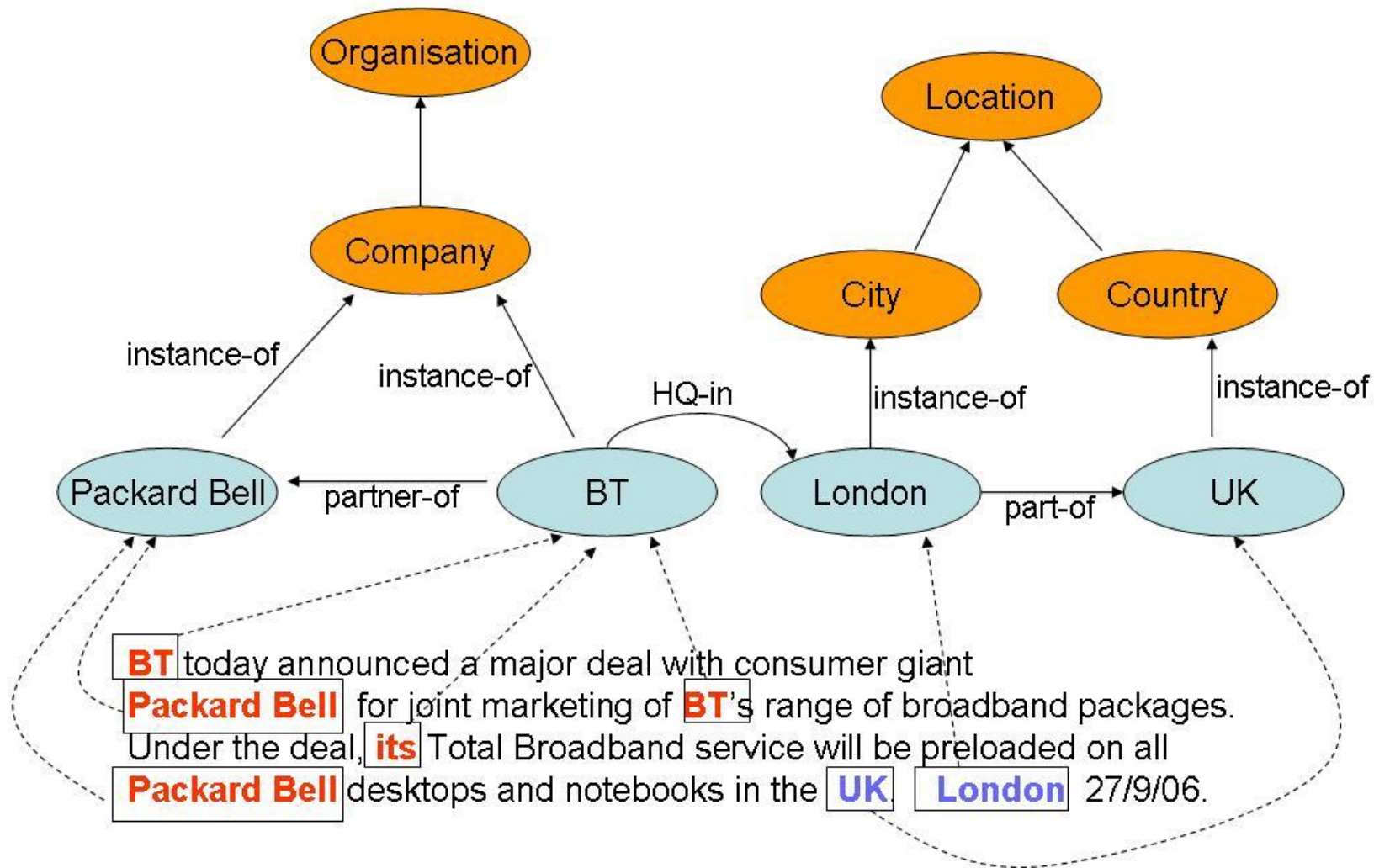- different words, same meaning   disability legislation

    equal opportunity laws

- different words, related meaning

    - leading to inheritance (and other) reasoning

    organisation

    company   charity   trade union

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Semantic Annotation

Semantic Browsing

Microsoft Corporation is a Public Company located in United States and Worldwide. Designs, develops, manufactures, licenses, sells and supports a wide range of software products. Its webpage is www.microsoft.com. It is traded on NASDAQ with the index MSFT. Key people include:

Bill Gates - Chairman, Founder

Steve Balmer - CEO

John Conners - Chief Financial Officer

Last year its revenues were $36.8bn and its net income was $8.2bn.

About the versions | Low Grap

2005, 09:56 GMT

Printable version

Microsoft $32m

...fined 33bn
) following
by South

Windows software by South Korea's Fair Trade Commission.

Microsoft was accused of "hurting the interest of consumers"

Regulators ordered Microsoft to introduce a version of Windows which enables the embedding of services by other software companies.

The news came as Microsoft announced plans to invest $1.7bn in India.

Chairman Bill Gates said the company planned to increase its workforce in the country "to 7,000 over the next three to four

E-Commerce
Economy
Companies
Fact Files
Politics
Health
Education
Science/Nature
Technology
Entertainment

Have Your Say
Magazine
In Pictures

Happening
Event
Situation
TimeInterval
Object
Agent
Location
Product
Service
Statement
Account
Brand

Classes   Entities

Place Links

Internet

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Precision in Semantic Web Search

- Semantic Search could match
  - a query**:** *Documents concerning a telecom company in Europe with a new director*
  - With a document containing**:** *"At its meeting on the 10th of May, the board of the UK company Vodafone appointed John Smith as Chairman"*
- Ontology-based search engines can do the required reasoning:
  - Vodafone is a mobile operator, which is a kind of telecom company;
  - Vodafone is in the UK, which is a part of Europe;
  - Chairman is a type of director

Semantic KM at BT

- SEKT FP6 integrated project (coordinator)
  - Completed 12/06
  - www.sekt-project.com
  - Semantic search tool in use internally
    - BT Digital Library
    - Expertise location
- ACTIVE FP7 IP (coordinator)
  - Began 1/3/08
  - www.active-project.eu
  - Integrating semantic web and web 2.0 technology
  - Modelling and managing knowledge processes

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Information Integration
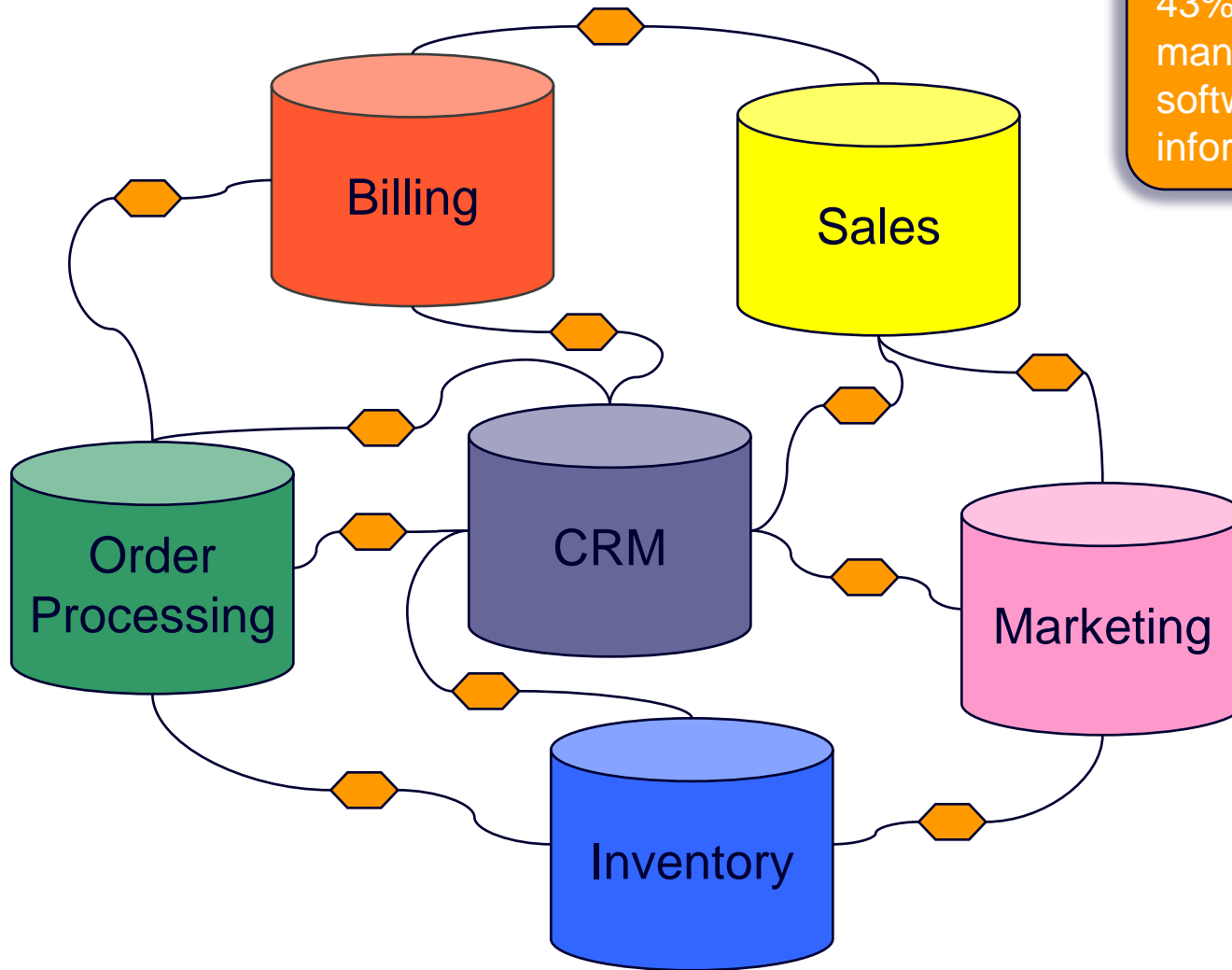
43% of businesses resort to manual processes and/or new software when integrating information for reporting

Semantic Information Integration

Existing legacy systems "wrapped" in semantic technologies

Semantic Broker

Declarative definition of Business Rules

| Billing | Sales | CRM | Order Processing | Marketing | Inventory |

Reasoning enables inference of new facts from existing data sources

Based on lightweight, open standards from W3C

Easier integration with external sources of information

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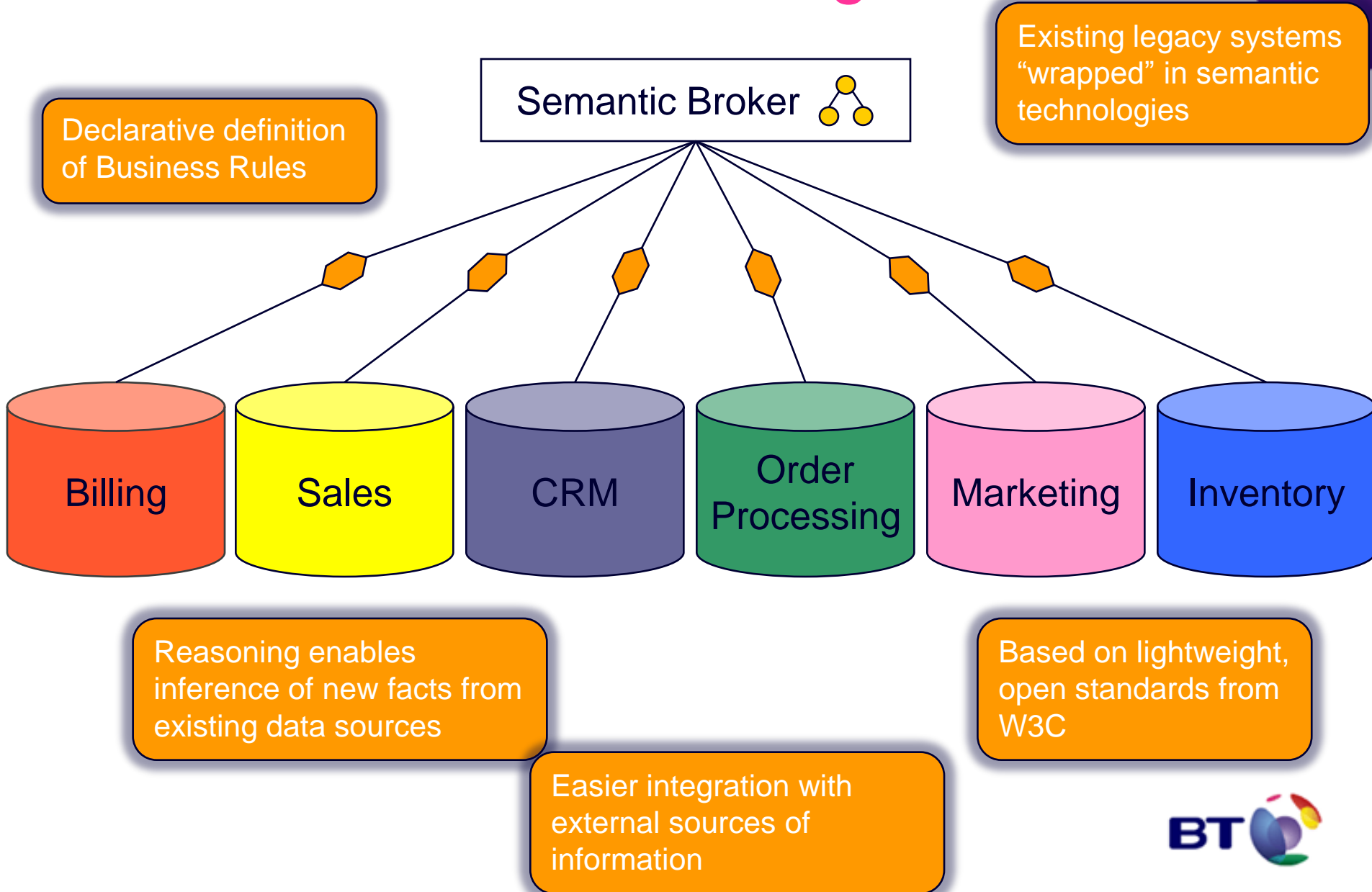
Semantic Data Integration - results

- One BT Business division is saving a verified €2.9m p.a. through the integration of its sales and billing data silos

- Ongoing work to link further information sources for greater benefit

- Vision is to offer a complete view of all information about a customer via a single interface (sales, billing, CRM, marketing, …)

Semantic VOIP management

- Business Opportunity
  - Dynamic and flexible management of BT VOIP platforms
  - Manage changing requirements (SLAs) from customers
    - Allowing real-time changes to SLAs and understanding impact
    - Automatically determining impact of network faults on customers VOIP service
- Solution
  - Unified Semantic Model of customers, network topology, calls data and SLAs (previously held in heterogeneous data silos)
  - Using logical reasoning to determine (in real time) the effects of changing circumstances, such as modifying SLAs

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Research prototype developed

- semantic modelling of several legacy data sources

- impact of requested SLA changes can be modelled and changes to system configuration suggested

- rules and formal models allow new information to be inferred

- linking Network Topology and Customer Inventory in one Semantic Model gives greater power (such as ability to identify impact to customer of failed router)

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Business Impact

- Research prototype delivered to internal customer

- Business Case accepted for deployment of full system in the BT Wholesale strategic IT stack
  - Mission critical deployment

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Motivation/Vision

Internet Today

➢ *1 billion users*
➢ *More than 30 billion pages (static)*
➢ *30% pages built by companies*
➢ *Only 27.000 "true" web services*
➢ *Most of services are in-house or restricted to closed environments*

Future Internet

➢ *2-3 billion users*
➢ *Internet of millions of Services*
➢ *Mobile Internet*
➢ *A network of equals*
➢ *"Prosumers"*
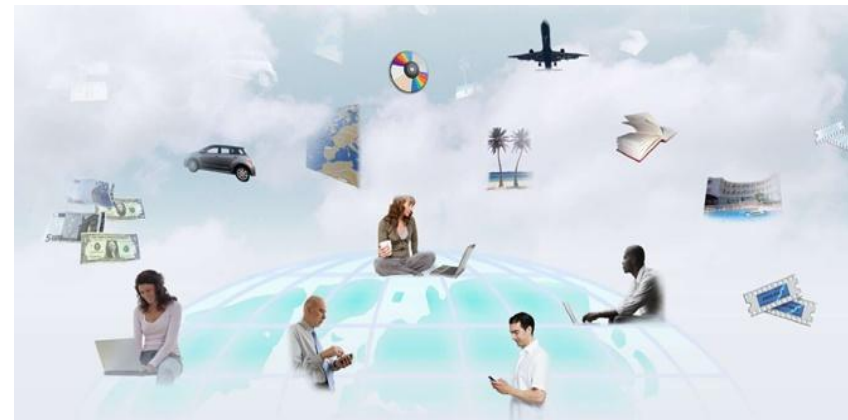
Software to Serviceware

- Computer Science is entering a new generation

- Previously: abstracting from hardware

- Now: abstracting from software

- All software resources as services in a *SOE*

  – The client needs a service, not software

  => From Software to **Serviceware**

Semantic Technology & Serviceware

Web Services
computational objects

Semantic Web Services - intelligent service discovery, interoperation, composition

Semantic Web
machine-processable info

WWW
static, unstructured info

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Semantic Service-oriented Architectures

- Semantic service descriptions
  - Functional and non-functional properties

- (semi-)automation of human intensive tasks
  - Service Discovery, Adaptation, Ranking, Mediation, Invocation

- Frameworks:
  - **SAWSDL (WSDL-S):** Semantic annotation of WSDL descriptions
  - **WSMO:** Ontologies, Goals, Web Services, Mediators
   - www.wsmo.org

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Semantic Serviceware

- ## On an Internet with
  - Millions of services
  - Millions of service prosumers

- ## Semantics will be essential
  - **Discovery**
  - **Interoperability**
  - **Scalability**

BT Ribbit Acquisition

- BT acquired ***Ribbit*** (www.ribbit.com) in 2008 for $100m

- Ribbit has implemented and exposed a full set of lightweight RESTful telecoms services over the web

- ***Ribbit*** is a platform for building web-based Telco applications

- The Ribbit community is well established with >10000 developers

- SOA4All is investigating application of semantic technology to Ribbit
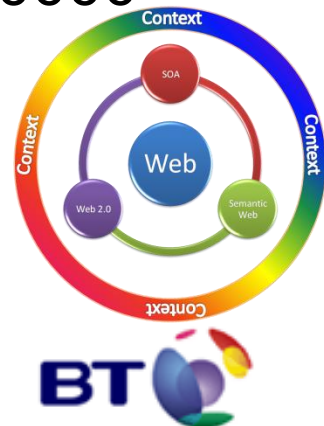
- Vision

  Allowing non-programmers to find and consume services on the web supported by communities, semantics and Web2.0-style interaction

- Benefit

  Driving revenue from BT and hosted 3rd party services. Identifying best practice for Soft Telco

- Innovation

  Combining community, semantics and context supported mashups - opening up new markets for service providers
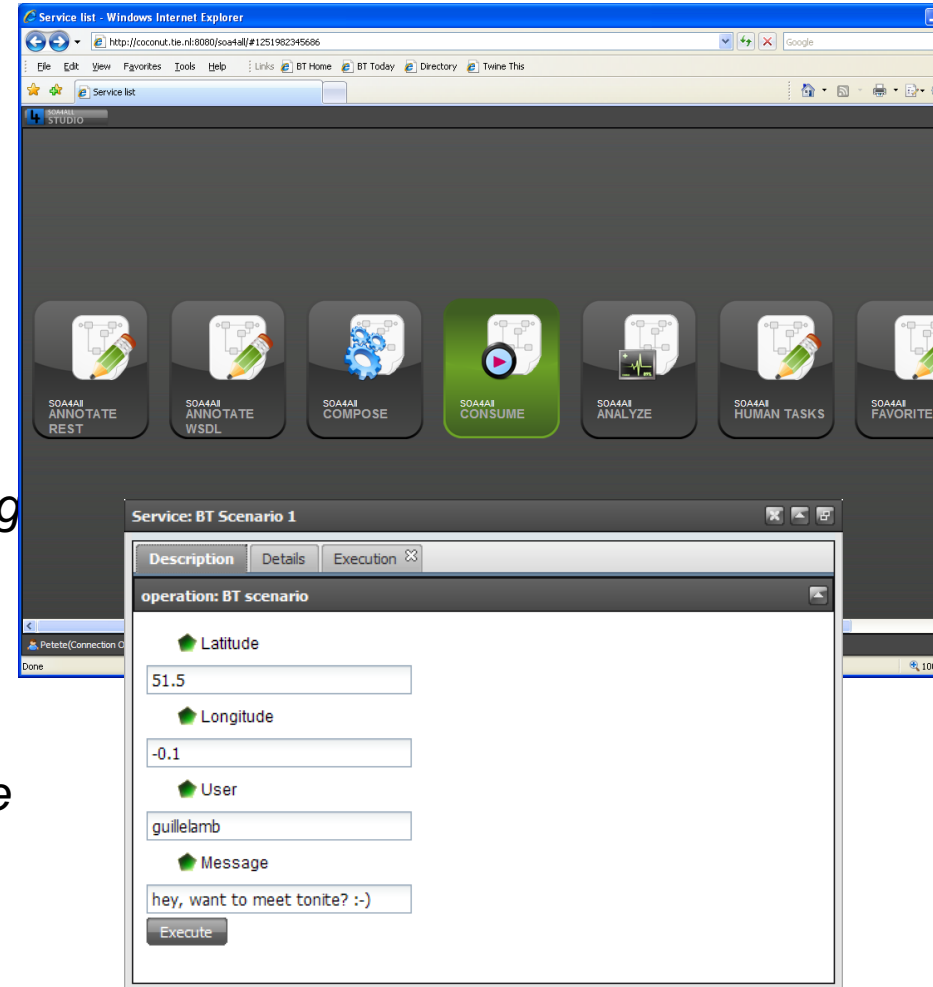
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Semantic Business Intelligence

- Today's BI solutions
  - focus on an organisation's structured data (20%)
  - **ignore the 80%** unstructured information
    - webpages, emails, slides, documents, …
  - **ignore the tens of thousands** of external items in news articles, customer forums, blogs, …

- Semantic technologies can help
  - Information Extraction – identifying people, places, organisations, trends, sentiment in unstructured information
  - Information Fusion – uniform access to multiple heterogeneous (structured and unsstructured) data silos

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Semantic BI

Client Applications

- -

Semantic Queries

Business Rules

Domain Ontology

News feeds

Web pages

Information Extraction

Semantic Data Integration

Unstructured

Structured

Databases

Documents

E-mails

Data Sources

BT
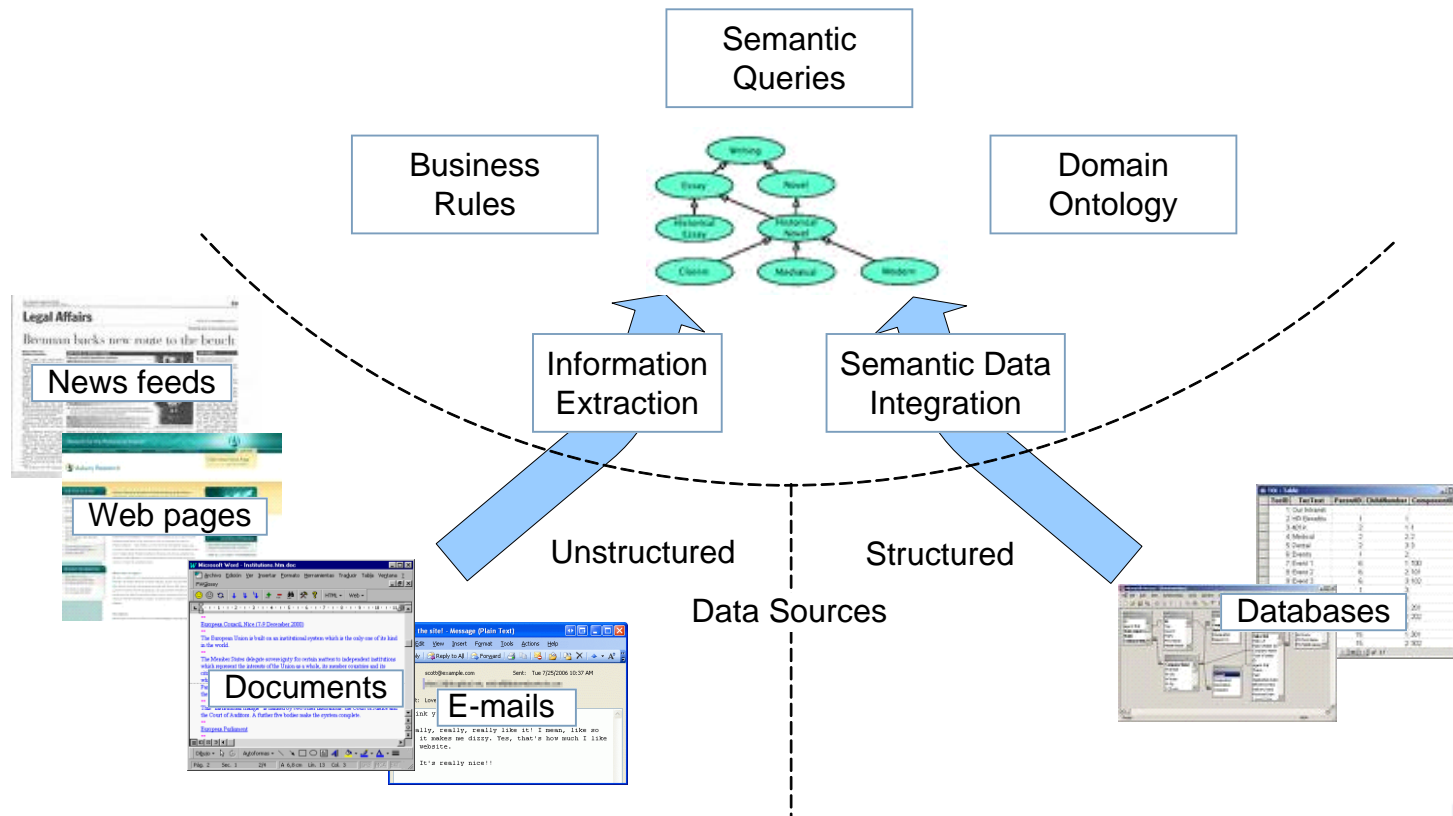
Information Extraction - Event Recognition

…Last month, white knight AcqCo won the day with a £350m bid for TargCo…

…The bidding war for OldCo finished today when NewCo offered €1.2bn…

…OneCo and TwoCo will join forces to create the largest company in the Sector, valued at $3.4bn…

Event	Acquirer	Acquiree	Mergees	Value	Date
Acquiistion	AcqCo	TargCo		£350m	November 2008
Acquisition	NewCo	OldCo		€1.2bn	14/12/08
Merger			OneCo, TwoCo	$3.4bn	

Information Extraction – Sentiment Analysis

1. …I have had Broadband Plus from NewCo for a month and I have found that their upload speed sucks…
2. …OldCo have launched a new suite of broadband services and I have got their Super offering. So far, I am reasonably happy with the service….

Post	Author	Source	Brand	Topic	Polarity	Weight	Date
1	John Smith	TelcoBlog	NewCo	Broadband Plus	Negative	-4	November 2008
2	John Brown	TelecomForum	OldCo	Broadband Super	Positive	+3	10/12/08

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Semantic BI – benefits

- ## Better use of unstructured information
  - Rationalization of unstructured data elements into disciplined data sets so that analytical tools may act on them as though they were structured

- ## Business intelligence products will incorporate better (semantic) search
  - Searching for meaning not the words used to represent the meaning

- ## Information fusion
  - Seamless simultaneous querying of multiple data sets (e.g. querying multiple data sources simultaneously to generate a report on a particular customer or product)

- ## Intelligent analysis of customer behaviour
  - Extraction of metadata revealing how users access the data (such as which products different shoppers compare in an online retail environment)

- ## Improved understanding of customer sentiment
  - Intelligent analysis of customer interactions giving interpretation of customers sentiment will overlay related structured data

- ## Exploitation of external information for enhanced BI
  - semantic technologies will analyze data from outside the enterprise (such as customer sentiment revealed in blogs and social networking facilities)

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SBI Demonstrator

- 14000 blog posts, news items etc over 6 month period

- BT broadband services + 10 competitors

- Demonstrate how information extracted from unstructured text can be combined with database information to explore relationships between events and opinions, and business performance
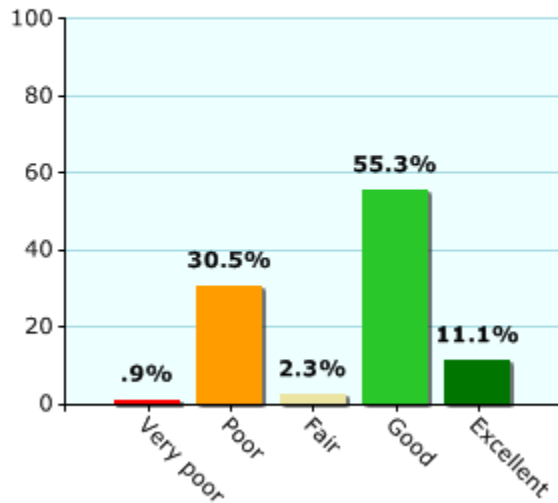
COGITO® Monitor

Driver | **Time period** | **Sources** | **Best & Worst** | **Statistics** | **Brand filter**

Reset

GRAPHS

Ratings Average
Competitive Positioning
Ratings Distribution
Historic Ratings Average
Historic Ratings Distribution
Ratings Distribution by Product
Influencers

Product/service: | Feature/part: | Quality:

(ALL)
(GENERAL)
Option 1
Option 2
Option 3

Ratings distribution detail

.9% Very poor — 30.5% Poor — 2.3% Fair — 55.3% Good — 11.1% Excellent

... fixed telephone operator in the United Kingdom and a leading provider ... BT offers its broadband services through BT Retail, BT Global Services, BT ... responsible for sales to consumers and SMEs. It includes BT Business ... roviders (ISPs).

TELECOMMUNICATION TELECOMMUNICATION **TELECOMMUNICATION**

Post time: between **13/04/2008** and **13/10/2008**

3.45

EXPERT SYSTEM

Driver	Time period	Sources	Best &

Reset

Brand:
Bt
Demon
Eclipse
Madasafish
Namesco
O2

Line:
(ALL)
(GENERAL)
Adsl
Cable
Mobile

Product/se
(ALL)
(GENERAL)
Option 1
Option 2
Option 3

Bt

British Telecom (BT) is the main incumbent fixed telep
of telecommunications services in Europe. BT offers its
Wholesale and BT Openreach. BT Retail is responsib
Broadband and other BT Internet Service Providers (IS

☐ **Comparison**

🇬🇧 **TELECOMMUNICATION** TELECOMMUNICATIO

Post time: between 13

Date	Type	Event
16/07/2008	LAUNCHING	BT launches new Home Hub
16/07/2008	LAUNCHING	Backed by a major ad campaign, BT Total Broadband is launching a new Home Hub with the latest "N" standard wireless technology which provides a more efficient wireless signal.
21/07/2008	INVESTING	BT said that it will fund the investment by suspending its share buyback programme, a move that has drawn criticism from shareholders and competitors.
21/07/2008	INVESTING	TalkTalk is likely to lose out from BT's investment in fibre optics as it is probable that BT would no longer let the company piggyback on its service once fibre optics are fully installed.

— Bt   — Bt sales

EXPERT SYSTEM
SEMANTIC INTELLIGENCE

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Solution Design - Challenges

- For large customers, BT often needs to combine multiple products and services in to complex *solution designs*
  - Hard to publish information in a useful way
  - Difficult to find previous relevant designs
  - Hard to find people with relevant experience to the current design
  - Difficult to extract management information

Improving the Solutions Design process

An enhanced **semantic** wiki developed to provide:

- a collaborative forum for document creation and sharing
- a forms facility for easy information entry
- semantic data modelling

- the ability to model relationships
  - John Smith is an expert in MPLS
  - Cisco-9000 is a kind of router

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Semantic Wiki:
Answering Questions

- Allows information to be entered in a structured form

- Allows answers to questions like find…

   … all solutions involving IPX product

   … all project managers based in Germany

   … ten biggest bids in Latin America

   … all solution designers who have worked with Nortel

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Semantic Wiki:
Reasoning & Maintenance

- Reasoning

  – France is in Europe; Paris is in France; John Norton has worked on a solution design for Paris Metro

  → John Norton has worked on solution design in Europe

- Maintenance

  – Does every bid have one bid manager?

  – Is there a service with more than one owner?

  – Does every project have a start date and end date and is the end date later than the start date?

  – Are all service bundles consistent?

  – Do all service bundles offered in Germany consist only of services available in Germany?

BT

802045827   my talk   my preferences   my watchlist   my contributions   log out

page   discussion   edit with form   edit   history   delete   move   protect   watch   refresh

Proposal: Smith and Williamson

search

Go   Search

Key details   [edit]

Principal author	Ian Thurlow
Customer name	Smith and Williamson
Bid manager	Paul Warren
Reference number	BP0108
Due date	2009/08/12

Executive summary   [edit]

| **Customer vision** | Currently, Smith and Williamson have internet connectivity to their Head Office in Edinburgh via a 2M Internet circuit provided by Cable & Wireless. Due to an increase in traffic and the need to be flexible as the business grows, Smith and Williamson would like to explore alternative suppliers that can provide flexibility as well as resilience in their solution. |

Trusted sites   100%

Proposal: Smith and Williamson - BidUnit - Microsoft Internet Explorer provided by BT Webtop

http://semantic.info.bt.co.uk/bidunit/index.php/Proposal:_Smith_and_Williamson   RW

File   Edit   View   Favorites   Tools   Help

Links   BT Library   Apophenia - Wikipedia, the free encyclopedia   Haynes Ball Solicitors - BidUnit   Add page with form - BidUnit   All pages - BidUnit

Proposal: Smith and Williamson - BidUnit

Page

Customer's needs	Flexible/resilient Internet connection to Smith and Williamson's head office.
BT's high level solution	BT recommends that Smith and Williamson migrate their services to BT Net Premium service, giving better Service Level Agreements and Service Level Guarantees. Failover circuit to provide full resilience.
Comliance with customer request	This needs to be discussed. Comments welcome.

Customer issues   [edit]

Description	1) Business likely to grow by 15% over next six months. Expected increase in Internet traffic to be discussed with Smith and Williamson. Who is the best person to contact? **Suggest that you contact Nick Bracewell - 0131 123 4567**
Solution and benefit	To be discussed once we know expected increases in Internet traffic.
Proof	To be considered

Description	2) Resilience is very important to Smith and Williamson. What services are BT currently offering, and at what cost?
Solution and benefit	To be discussed/agreed with specialists.
Proof	To be discussed

Products   [edit]

Product BT Net Premium

Trusted sites   100%

start   M   P.   l..   Search Desktop   EN   09:52

Proposal: Smith and Williamson - BidUnit - Microsoft Internet Explorer provided by BT Webtop

http://semantic.info.bt.co.uk/bidunit/index.php/Proposal:_Smith_and_Williamson

RW

File   Edit   View   Favorites   Tools   Help

Links   BT Library   W Apophenia - Wikipedia, the free encyclopedia   Haynes Ball Solicitors - BidUnit   Add page with form - BidUnit   All pages - BidUnit

Proposal: Smith and Williamson - BidUnit

Page

Categories: Proposals | Executive summaries | Customer hot buttons

Facts about Proposal: Smith and Williamson ⓘ

RDF feed

Complies with	This needs to be discussed. Comments welcome.
For a customer	Smith and Williamson + 🔍
Has bid manager	Paul Warren + 🔍
Has customer issue	1) Business likely to grow by 15% over next six months. Expected increase in Internet traffic to be discussed with Smith and Williamson. Who is the best person to contact? **Suggest that you contact Nick Bracewell - 0131 123 4567**, and 2) Resilience is very important to Smith and Williamson. What services are BT currently offering, and at what cost?
Has customer needs	Flexible/resilient Internet connection to Smith and Williamson's head office.
Has customer vision	Currently, Smith and Williamson have inter ... y as well as resilience in their solution.
Has due date	12 August 2009 + 🔍
Has high level BT solution	BT recommends that Smith and Williamson migrate their services to BT Net Premium service, giving better Service Level Agreements and Service Level Guarantees. Failover circuit to provide full resilience.
Has principal author	Ian Thurlow + 🔍
Has proof	To be considered, and To be discussed
Has reference number	BP0108 + 🔍
Has solution and benefit	To be discussed once we know expected increases in Internet traffic., and To be discussed/agreed with specialists.
Proposes product	BT Net Premium + 🔍

This page was last modified on 7 July 2009, at 08:38.   This page has been accessed 14 times.   Privacy policy   About BidUnit   Disclaimers

Powered By MediaWiki

http://semantic.info.bt.co.uk/bidunit/index.php/Special:SearchByProperty/Proposes-20product/BT-20Net-20Premium

Proposes product BT Net Premium - BidUnit

802045827   my talk   my preferences   my watchlist   my contributions   log out

special page

Proposes product BT Net Premium

A list of all pages that have property "Proposes product" with value "BT Net Premium".

- Proposal: Smith and Williamson + ◑
- Proposal: Phoenix + ◑

Property [Proposes product]   Value [BT Net Premium]   [Find results]

navigation
- Main Page
- Community portal
- Current events
- Recent changes
- Random page
- Help

search
[   ]
[Go]   [Search]

toolbox
- Special pages

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File Edit View Favorites Tools Help

Links BT Library W Apophenia - Wikipedia, the free encyclopedia Haynes Ball Solicitors - BidUnit Add page with form - BidUnit All pages - BidUnit

Proposal: Phoenix - BidUnit

802045827   my talk   my preferences   my watchlist   my contributions   log out

page   discussion   edit with form   edit   history   delete   move   protect   watch   refresh

Proposal: Phoenix

Contents [hide]

1 Key details
2 Executive summary
3 Customer issues
4 Products

navigation

- Main Page
- Community portal
- Current events
- Recent changes
- Random page
- Help

search

[Go] [Search]

toolbox

- What links here
- Related changes
- Special pages
- Printable version
- Permanent link
- Main contributors
- Browse properties

Key details   [edit]

Principal author	Ian Thurlow
Customer name	Phoenix
Bid manager	Paul Warren
Reference number	ZX100
Due date	2009/08/16

Executive summary   [edit]

Customer vision	Phoenix are expanding their operations in Stoke and Brighton. Phoenix's Internet traffic is expected to increase significantly over the next year. Phoenix also want to simplfy their data and communications infrastructure and reduce costs.

Note: Phoenix have been with their current provider for over two years, they are looking |

Done   Trusted sites   100%

start   M   P.   I..   Search Desktop   EN   09:58

Benefits

- Easy information entry
  - consistent format
  - shared repository
- Improved knowledge re-use
  - easy to find relevant previous work
  - easy to find people with relevant experience
- Improved management information
  - better access to info through structured queries
  - 'how many solutions involve service X'
  - 'how much Y do we sell in North America'

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- **Specific application in the health sector**

- Semantic Technology uptake

BT Global Services

- Provides networked IT solutions for multi-site organisations (>35% total BT revenue)

- The Health division has a prominent role in ~€10bn UK NHS National Programme for IT

- ~€3bn of contracts for
  - Networking
  - National application service provider
  - Local application service provider for London

Health IT is heterogeneous & distributed
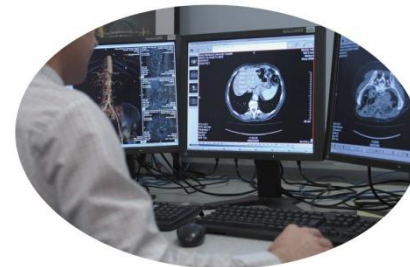

Pathology

Hospital ward

Community health
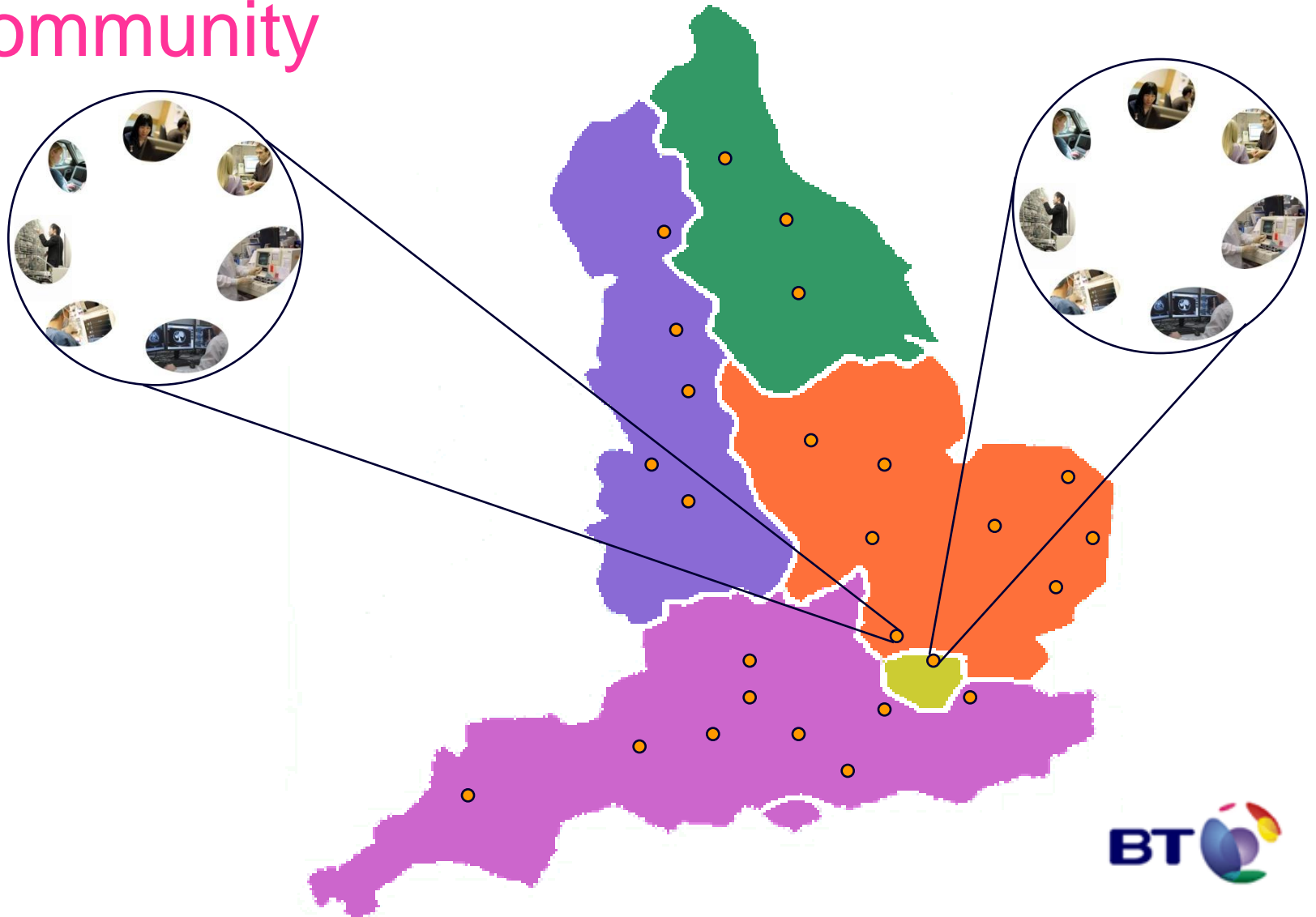
Pharmacy

General practice
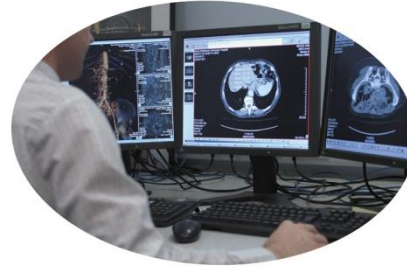
Surgery

Radiology

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Pattern repeated in each health community

Patient centric Health IT

Patient journey

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NHS Connecting for Health

- **National Care Records Service**
  - A live, interactive patient record service accessible by health professionals whether they work in hospital, primary care or community services

- The core of the NHS CRS is provided by the **Spine**
  - Central summary record

- Detailed patient information stays local
  - records of detailed history of care,medical conditions, tests, X-rays scans and other results.

⇨ A large distributed system containing semantically heterogeneous information that must be integrated to some degree around individual patient care, with aggregated data sent to the Spine
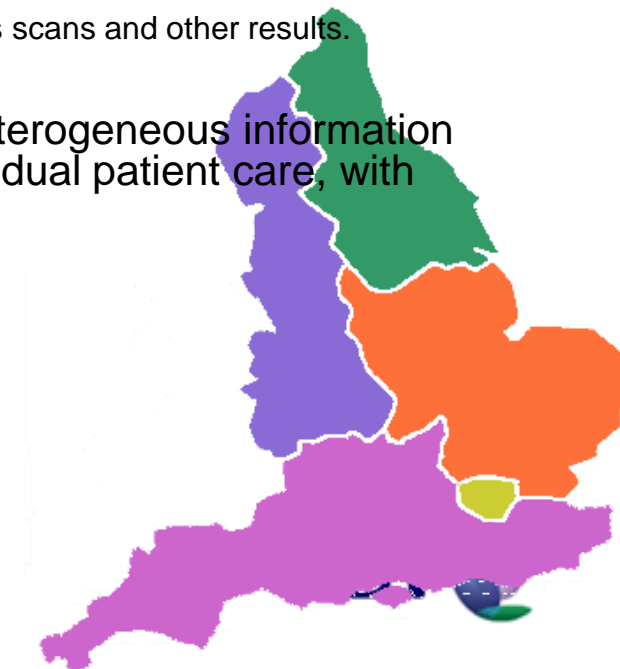
Tools for Healthcare IT Integration

- **SNOMED-CT** - Consistent use of medical vocabulary
    - Systematised Nomenclature Of Medicine - Clinical Terms
    - Merger of UK and US efforts with a joint editorial board
    - Original development – College of American Pathologists
    - Now managed by an international organisation based in Denmark
    - Large reference terminology (>400,000 concepts)
    - Aim to be machine interpretable for the exchange, aggregation, analysis of clinical data and to enable clinical decision support

    ⇨ *semantic technology!*

- **HL7 v3** - Consistent messaging between applications
    - Specifications for consistent exchange of information between clinical applications
    - SNOMED-CT provides a vocabulary whilst HL7 provides the data model with which messages are built

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Patient centric Health IT
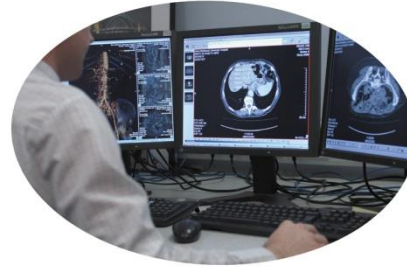
HL7 messages containing SNOMED-CT terms

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Semantic Technology & Health

- SNOMED-CT

  – Standard medical ontology (a "terminology")

  – 400000+ concepts

- Now expressed formally in OWL

  – Reasoning

  – Consistency checking

SNOMED-CT & OWL

SNOMED-CT

- Concept based
- Clear separation of lexical representation and conceptualisation
  - **Whipple's procedure** and **pancreatoduodenectomy** terms represent the same medical concept
  - **Cold** can mean **cold temperature** or a **common cold**

OWL

- SNOMED concept directly corresponds with **OWL Class**
  - Class(Appendicectomy)
- **RDFS label** can be used to represent term labels (synonyms)

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Pure subsumption hierarchy

SNOMED-CT

- has an '*is-a*' relationship equivalent to logical implication / subsumption

- A patient with asthma implies a patient with a respiratory disorder

Asthma is-a Respiratory-disorder

OWL

- Corresponds to OWL subclass

  – SubClassOf(Asthma Respiratory_disorder)

Composite Concepts: Property based definitions

SNOMED-CT

- Relationships with other concepts that partially or fully define the concept of interest

- Description logic reasoner used to classify concepts

OWL

- Can be modelled as existential restrictions

- Description logic reasoner used to classify classes

*An **appendicectomy** is defined as a surgical procedure using the method **excision** at the site **appendix structure***

*EquivalentClasses(**Appendicectomy***
  *ObjectIntersectionOf(**Surgical_Procedure***
   ObjectIntersectionOf(
      *ObjectSomeValuesFrom(**procedure_site Appendix_Structure***)
      *ObjectSomeValuesFrom(**method Excision**))))*

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Post coordination

SNOMED-CT

- Not designed to be complete 'out of the box'

- Extensible at the point of data entry through 'post coordination'

*Concepts for **kidney, excision,** and **left** exist: can create a new concept 'left kidney excision'*

intersectionOf(Excision
  restriction(procedure-site someValuesFrom
    intersectionOf(kidney
   *restriction(laterality someValuesFrom left))))*

OWL

- Corresponds to anonymous class expressions of OWL-DL

Semantic reasoning at point of care

- Description Logic reasoning is required in the live environment

- Why do you need semantic reasoning in the live environment?

  - *Post coordination* (i.e. allowing users – clinicians - to create new terms)

  - Can never enumerate all required medical concepts in advance

  - New concepts are created by combining and/or extending old terms and reasoning determines the correct logical place for new concepts

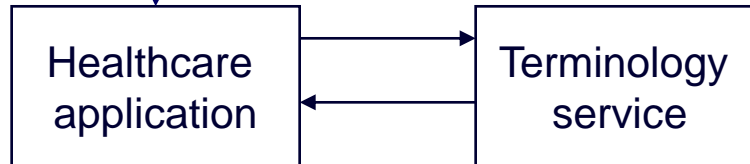 - Creation of new anonymous class expressions (in OWL speak)

1 Clinician records clinical data using novel
expression e.g. patient has almond allergy
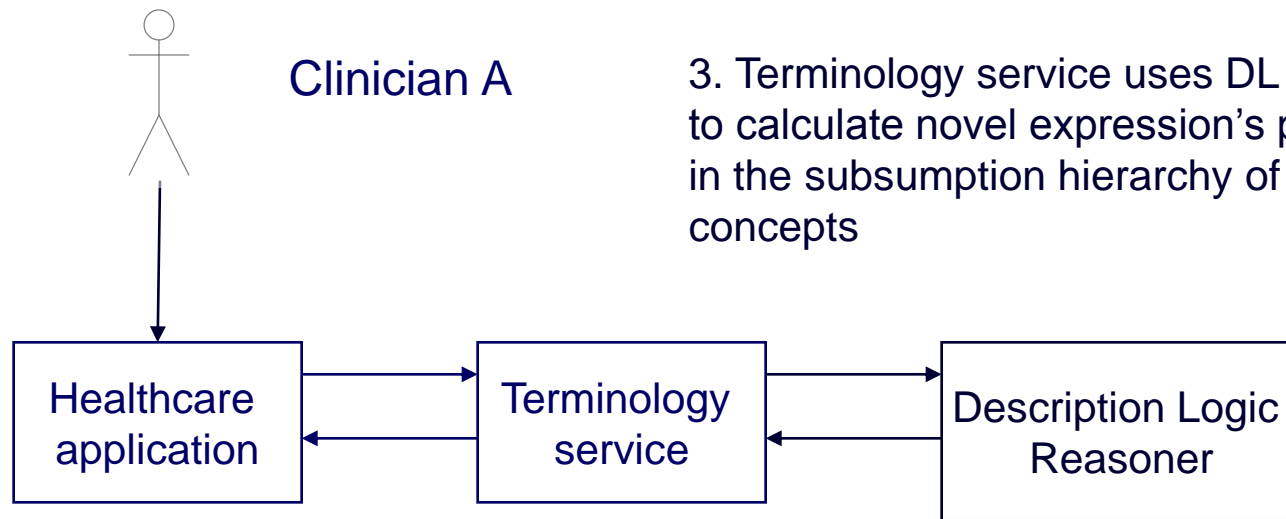`Allergy+caused_by+almond`

Clinician A

Healthcare
application
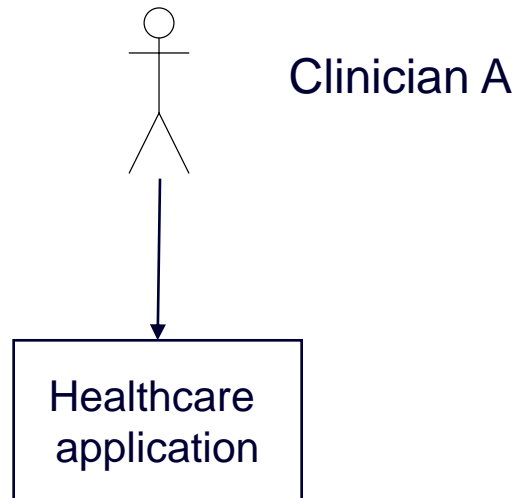
Clinician A

2. Application registers novel expression with terminology service
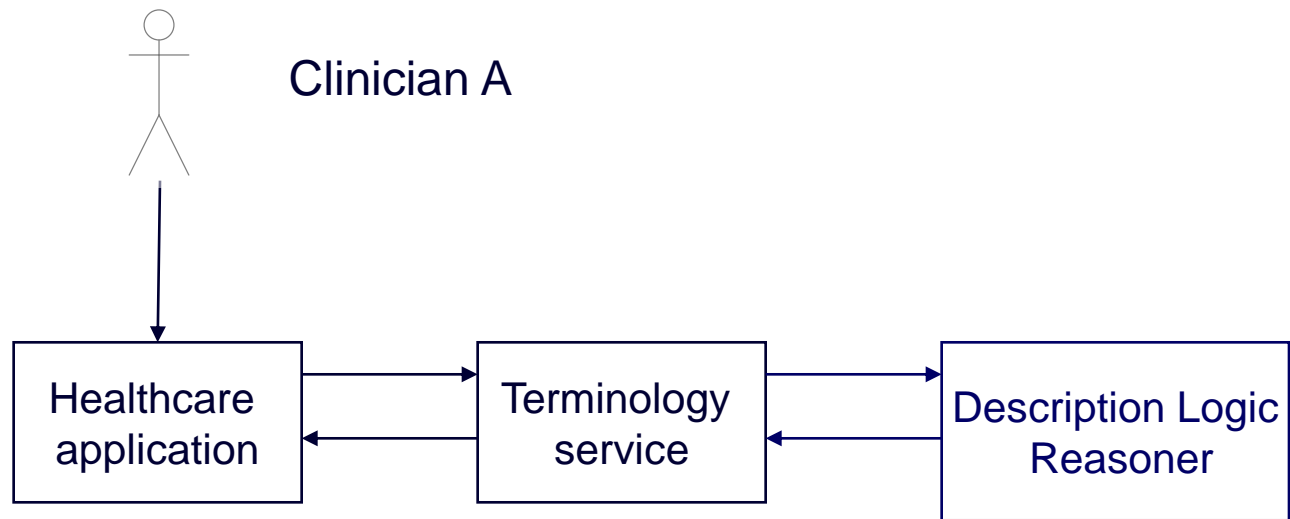
| Healthcare application | Terminology service |

BT

Clinician A

3. Terminology service uses DL reasoner to calculate novel expression's position in the subsumption hierarchy of existing concepts

| Healthcare application | Terminology service | Description Logic Reasoner |

NB Specification of property values make this a non-trivial task

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Clinician A

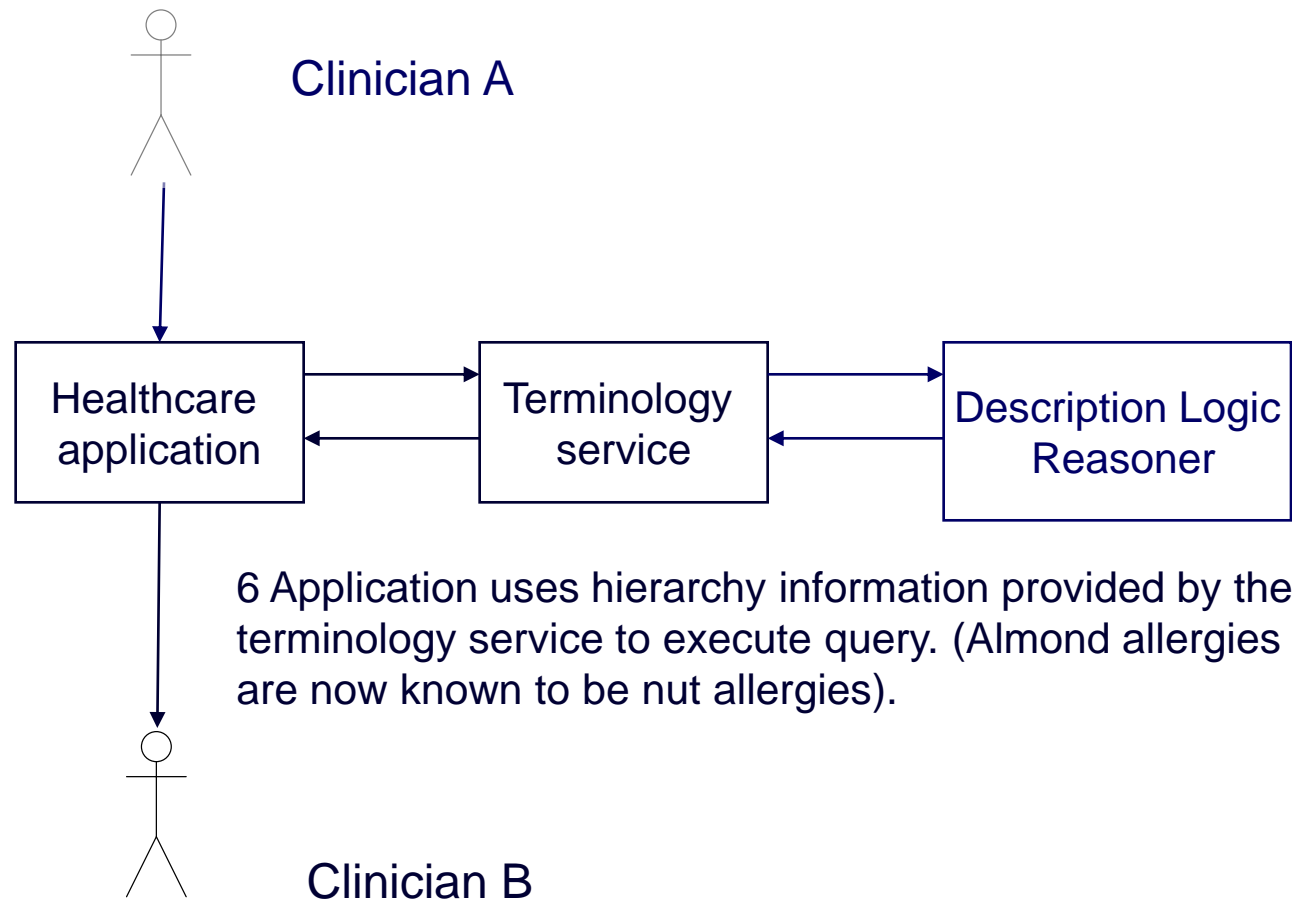Healthcare application → Terminology service → Description Logic Reasoner

4. Terminology service provides information to application on the subsumption hierarchy including the position of the novel expression e.g.

```
allergy+caused_by+almond is-a
        nut allergy
```

Clinician A

Healthcare application

Terminology service

Description Logic Reasoner
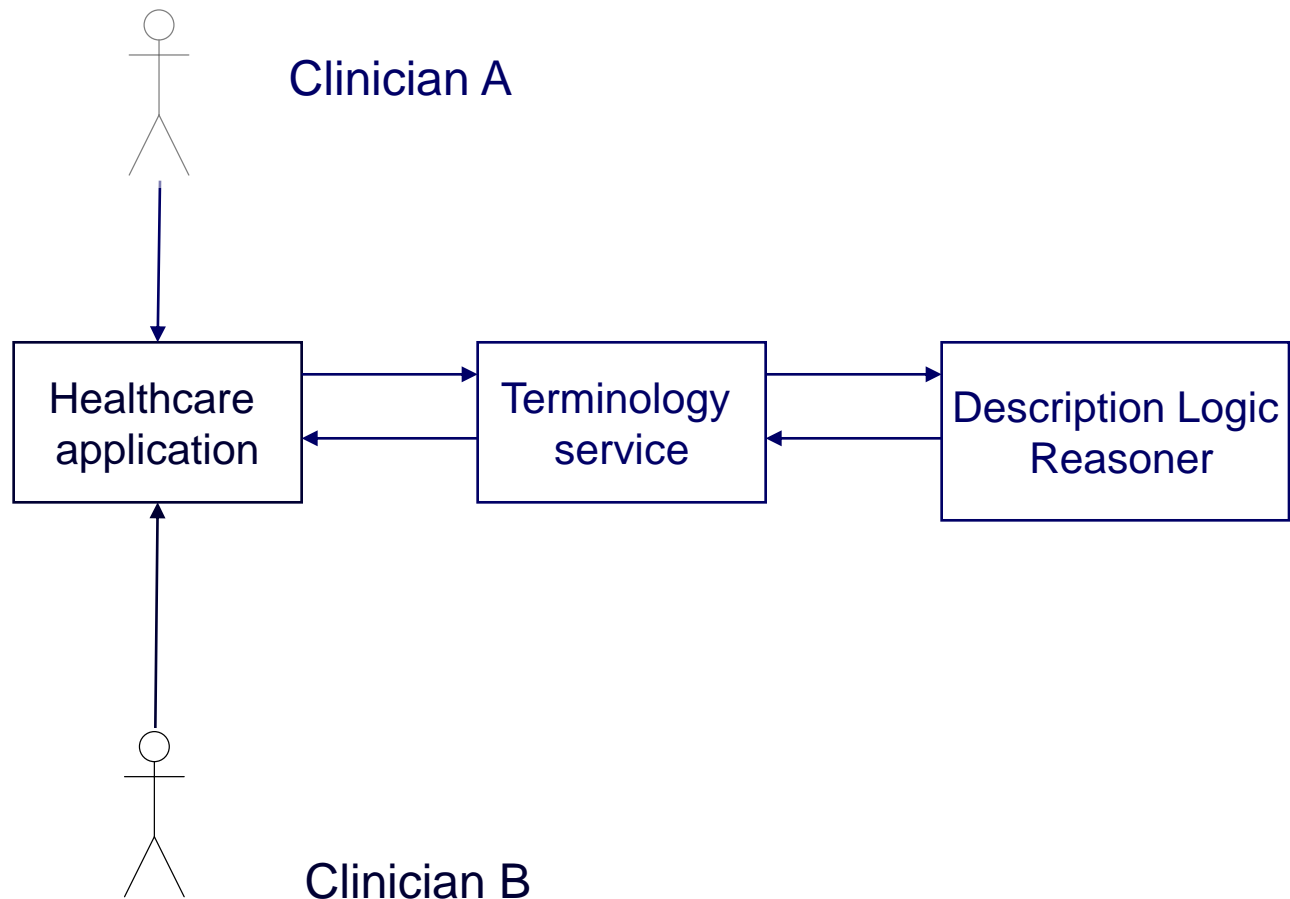
Clinician B

5 Clinician queries for patient data which contains novel expressions e.g. `Which patients have nut allergies?`

Clinician A

Healthcare application

Terminology service

Description Logic Reasoner

6 Application uses hierarchy information provided by the terminology service to execute query. (Almond allergies are now known to be nut allergies).
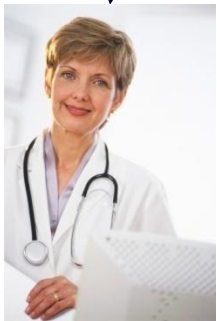
Clinician B

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Semantic reasoning – example 2

A procedure involving a laparoscope is a keyhole procedure: how is the system to determine the number of keyhole procedures if not explicitly stated to be such?

By use of a rule which states that use of laparoscope implies procedure was a laparoscopy, which is a kind of keyhole procedure

Pre-coordination

Post-coordination

Hernia Repair

Access Instrument?

Laparoscope
(implies keyhole procedure)

Q: How many 'Key hole' procedures?

Progress in BT

- Proof of concept using Semantic technology
  - evaluating a range of reasoners
  - FaCT++ Description logic reasoner from University of Manchester
  - ~30 mins to initially load over 400,000 concepts in SNOMED-CT
  - <10ms to calculate subsumption of simple anonymous class expressions shown in example above

- Work now handed over from research to development team

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Overview

- Brief introduction to semantic technology

- Applications
  - Knowledge Management
  - Information Integration
  - Service-oriented environments
  - Business Intelligence
  - ICT Solution Design with Semantic MediaWiki

- Specific application in the health sector

- **Semantic Technology uptake**

Semantic Technology uptake

- Semantic Technology is going mainstream…

  – Oracle – adoption of RDF in 10g

  – Reuters – all its information now available in RDF via Calais

    - *"Oracle Integrates Semantic Data into Workflows Using OpenCalais"*

  – BBC: programme information in RDF

  – Much start-up activity

    - *Radar Networks, Ontoprise, Ontotext, Metatomix, SEMgine, Hakia, ...*

  – SNOMED-CT, GO – the Gene Ontology, …

Semantic Technology uptake

- Semantic Technology is going mainstream…
  - Microsoft $100m acquisition of Powerset
  - Yahoo!/Google also active
    - Search Monkey & Rich Snippets
- Organisations which can help
  - ST International (www.sti2.org)
  - W3C (www.w3c.org)
- European Semantic Technology Conference
  - Real-world applications of semantic technology
  - Vienna, December 2-3 2009, www.estc2009.com

A couple of (non-)controversies

- Web 2.0 renders the Semantic Web redundant
  - Both are concerned with metadata (tags/ontological)
  - A continuum
  - Tag clouds for photos
    - → RDF for Open Calais
      - → OWL-Full for life-critical health ontologies

- 'Bottom-up' versus 'Top-down'
  - Appropriate technology for the task at hand
  - Massive annotation of text – bottom-up
  - Gene Ontology – top-down
  - OntoGen – combines the two – generates an ontology bottom-up from a corpus, to be refined 'top-down' by human

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Semantic Technology uptake

- Semantic Technology has applications both on and beyond the web

- Many sectors are using the technology today

    - See http://www.w3.org/2001/sw/sweo/public/UseCases/ for 26 further case study examples

- "Semantic technologies could revolutionize enterprise decision making and information sharing"

- PWC Technology Forecast, Spring 2008

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Thank you for your attention

Questions?