Enhancing Data and Processes Integration and Interoperability in Emergency Situations: A SWS based Emergency Management System

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Athens GA, Nov 06, 2006

DIP - Data, Information and Process Integration with Semantic Web Services

IST Project Number : FP6 - 507483

ECC: eGov use case within DIP

- Essex County Council is a large local authority, covering **1,300 square miles** in South East England (UK). Together with 12 District Councils and other agencies it delivers **services to 1.3 million citizens**
- Essex County Council largest local authority in Essex
- Case study partner: Leading e-Government WP
- Real Use Case Implementations of SWS in the e-Government sector
  - Intelligent Information Management

ECC: eGov use case within DIP

Essex County Council

- Real world experience in e-Government
  - Proof of concept
  - Apply SWS as an infrastructure in real e-Governmental scenarios improving the way in which multiple organisms (different departments within an organization, organizations and their customers, partners and suppliers) operate together to provide better services to the citizens
  - Prove the benefits of SWS for the Automation of the business processes
  - Use SWS technology to automatically generate governmental services on the fly from citizen-based requests
- Support and guide other WPs
  - Validate prototype products
  - Demonstrate usability application and benefits of DIP's tools and methods
- Raise awareness within the e-Gov community
- Stimulate take up of new technology

Motivation: Current situation in service delivery to the citizens

Essex County Council

- No central control in eGovernment
- 3 tiers of government providing different services to the citizen
- Essential services are provided by three tiers of government (National, County, and District or Borough) and also supported by service providers in the community and voluntary sector
- Tier partition: Difficult to find the appropriate service that fulfils the citizen's necessity

Motivation: Current situation in service delivery to the citizens

Essex County Council

- Delivery of Community services is affected by the complexity, fragmentation and latency of user demands and needs.
- Integration is a recognized problem
  - UK survey by Public Sector Forums and the Local Government Integration Practice (LGIP) – 2006
    - less than half (44.7%) of responding authorities had an integration policy
    - only 4% had fully implemented it
    - 42% had barely progressed
    - further 29% reported only moderate progress
- Changes in the service providing depending on government policies.
- SWS technology can alleviate this issues and provide better-valued services to the citizens.

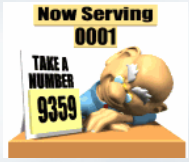
Motivation: Current situation in service delivery to the citizens

Essex County Council

- On-line services provided to the citizens are scattered trough several web pages, locally managed by different organizations
- Complicated when different agencies have to collaborate (notify changes to partner agencies) to provide a service to the user
  - Discover and retrieve data from a widely dispersed array of sources (within their own government authorities and agencies, across multiple tiers of government and externally)
  - Re-using data of different types held in heterogeneous formats
- Essex County Council has a coordination role in all this process
  - ECC's Information services: Sharing information with service delivery partners ('joined-up' services) to achieve a better service delivery to the public

SWS to solve Interoperability problems in eGovernment

- Aggregate and reuse all the information resources relevant to a given problem
  - Making them available for further request from partner organizations and individual citizens
- Improve relations between citizens and their government (improve departments interoperability)
  - Avoid too much paperwork
  - Avoid duplicate work
    (citizen having to notify several times to different departments)



  - Avoid departments keeping duplicate records in physical and electronic format (leads to inconsistencies)

Identifying relevant scenarios for SWS in eGovernment

- Creation of two compelling applications
- Change of Circumstances prototype
- eMerges: GIS-based emergency management system

CoC prototype

- Chosen from the subset of the twelve public services for citizens identified within the European Interoperability Framework for which the online sophistication is being benchmarked at national level:
  - Income taxes: declaration, notification of assessment
  - Job search services by labour offices
  - Social security contributions (Unemployment benefits, Child allowances, Medical costs, Student grants)
  - Personal documents (passport and driving licence)
  - Car registration (new, used and imported cars)
  - Application for building permission
  - Declaration to the police (e.g. in case of theft)
  - Public libraries (availability of catalogues, search tools)
  - Certificates (birth, marriage): request and delivery
  - Enrolment in higher
  - Announcement of moving (change of address)
  - Health related services (e.g. interactive advice on the availability of services in different hospitals; appointments for hospitals)

CoC scenario definition

- Change of circumstances “mother moves in”
- “A part-time single woman moves into a new rented house, in the same local authority area as her previous address, in order to look after her disabled 86 year old mother, whose previous address was also in the same local authority area”
- Multiple service-providing agencies need to be informed and interact in order to provide appropriate services/benefits to the mother and daughter

CoC scenario definition

- A citizen can be entitled to receive benefits from several agencies
  - Housing department of Chelmsford District Council, Work and Pensions, NHS, General practitioners, Caring homes, JobCentre plus (attendance allowance), Planning Department (building regulation permission)
  - ECC has a coordinating role in the whole process
- Complicated claiming of services/equipment nowadays
  - NHS, doctors, Occupational therapists, ECC, borough council and private companies involved.
  - Different ways of communication: web pages, email, DB records, etc – Scattered and heterogeneous (different formats and meanings).

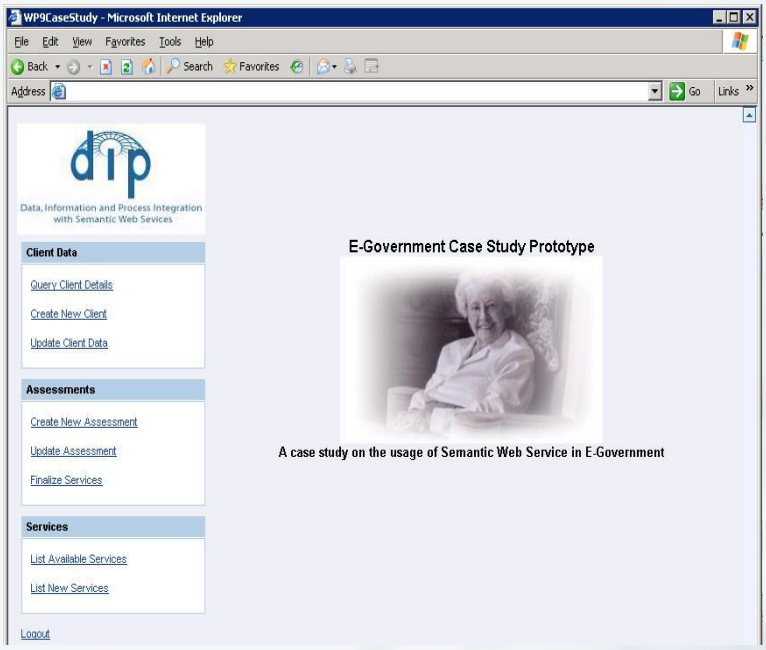
CoC scenario definition

- DIP prototype focuses on two agencies
- Community Care (Social Services - SWIFT)
  - Meals on wheels, carers, cleaners, etc.
- ELMS system (home equipment for disabled people)
  - Stair lifts, wheel chairs, crutches, etc.
- Created SWS to model these business processes
  - Automating communication/sharing of information
  - Further reasoning involved

Complications

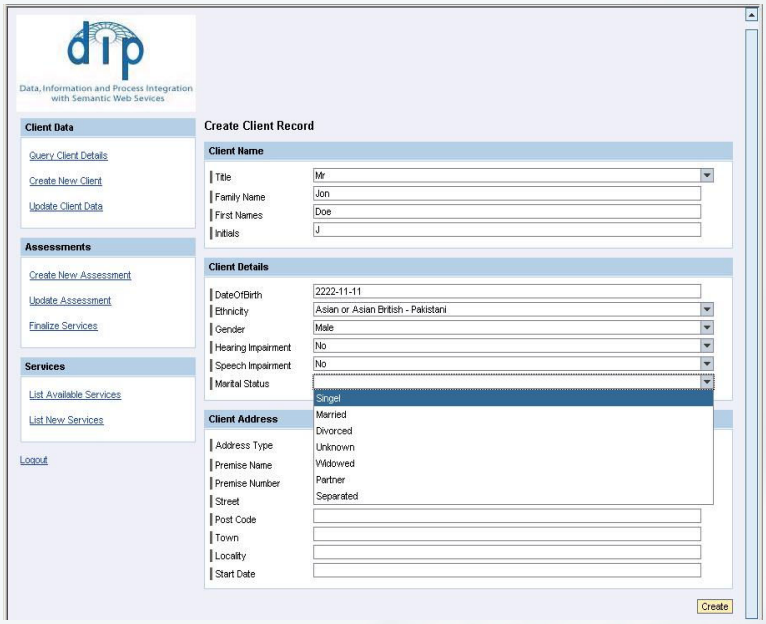
- Most of the problems experienced during the development of this prototype were not technical but ethical/legal
  - Security and confidentiality issues around SWIFT
  - Personal data is confidential and highly sensitive
- Data protection Act 1998
  - Places restrictions on organisations which collect or hold data which can identify a living person
  - *"Requirement to process data only for purposes compatible with that for which they were collected "*
- SWS objective is to integrate data from different heterogeneous and distributed sources but there are still legal barriers that have to be overcome.

CoC portal



- The portal administers a network of agencies (service/benefit providers)
- An agency registers itself on the portal
  - Fill in the fields: name, organization, contact person, partnership agencies
- Every registered agency publishes their service/s in form of Web Services
  - Have to be based on an agreed e-government ontology
  - Agencies can provide their own ontologies and their own goals and mediators
  - Provide an URL where the WS is published
  - An instance of the ontology class "agency" is created when all this information is submitted (stored in IRS-III)

CoC portal



- End user of the portal: case worker who is helping the citizen to report his/hers “change of circumstances” to different agencies
- Case worker registers new client, searches or updates his/hers information
- The client’s information submitted trough the portal is stored
  - and related in the underlying ontology as a new instance of the class “client”
  - Information stored in IRS-III server
- The case worker selects a goal from the portal
  - Change of address, marriage, hospitalization, moving in, winning lottery, etc… and the benefits/services entitled to the citizen are sent back from the execution of the WS behind the scenes
  - Automatic discovery, composition and invocation of SWS.

Benefits

- Reduction of duplicated data
- Reduction of the time and resources to find the desired information
- Saving time and effort to citizens and civil servants looking for the desired information: benefits/social help/etc
- Reduces cots in the public administration

eMerges prototype

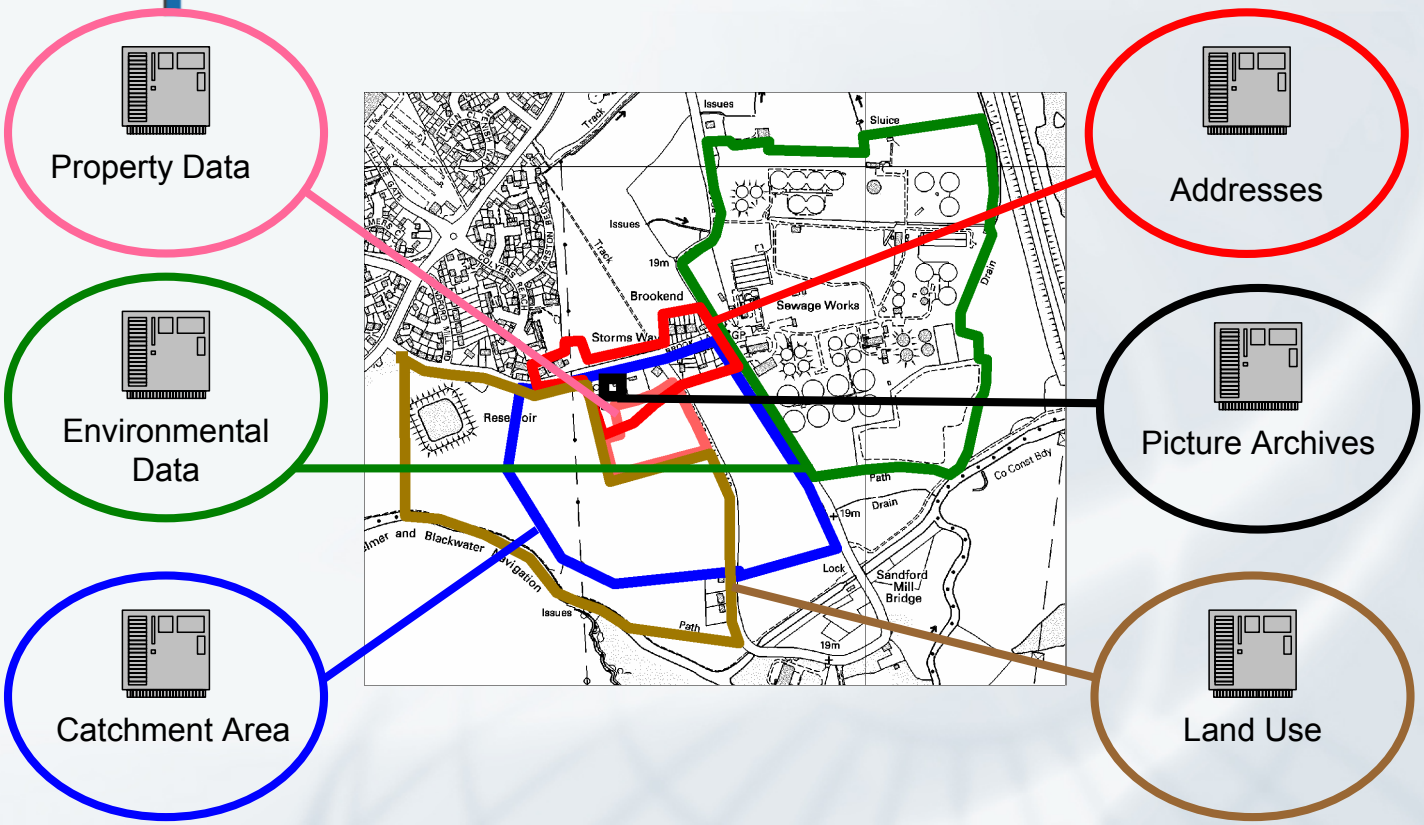
- Identify and hold interviews with relevant people to define the most compelling scenario
  - Within several departments in ECC
    - Highways & transport
    - Emergency planning
    - Work & pensions
    - Planning
    - Etc.
  - With external organizations
    - Ordnance Survey,
    - Meteorological office,
    - Districts and Boroughs (Cambridgeshire, Hertfordshire)
    - Emergency planning college.
    - Essex Fire Service, Police, BAA (Stansted).
    - Future contacts: Hospitals, Utilities companies, Environment agency, NHS.
    - Etc.
- Discovered the **potential of SWS applied to GIS**

Information needs in an emergency situation

- Wide range of agencies/ECC departments/emergency corps involved
  - need to exchange data/procedures
- Huge data provision and inter-agency communication required
- Different action plans depending on several parameters:
  - Type of problem, site, population affected, etc
- Gathering data in a manual or semi-automatic way is time and resource consuming
- GIS-based responses

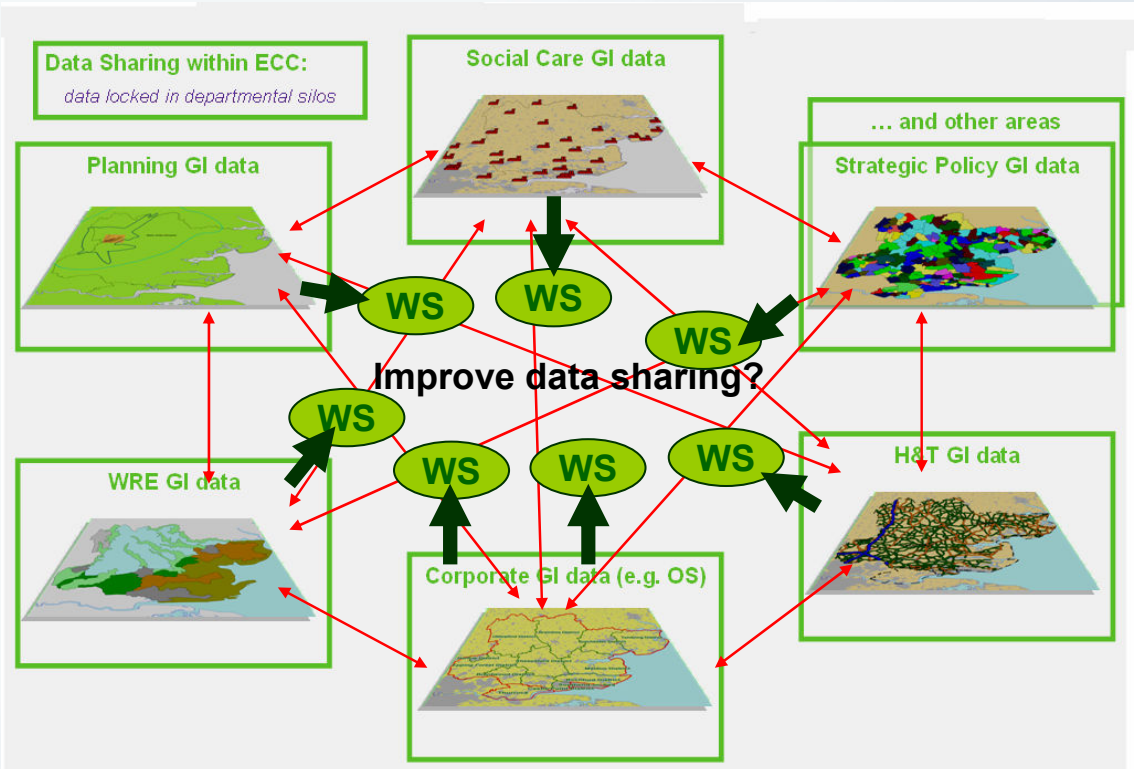
Spatial data in Essex: current situation

Essex County Council



Improve emergency-related information sharing

Essex County Council



Publishing emergency-related data/procedures through the internet allows to share information more easily

Improve emergency-related information sharing through WS

- WS allow a distributed model for data use across the internet, with the most appropriate source of a particular dataset publishing its information, to be consumed by others.
  - Web services allow just the right piece of information to be served, at the moment of need – the user no longer has to manage large holdings of digital map data.
  - Real-time access to data (specially important in an emergency situation)
- Allows emergency planning agencies and rescue corps to share information easily
- WS are autonomous and platform-independent
  - Described, published, discovered, orchestrated and programmed using XML artefacts.
  - Based on WS standards: SOAP, WSDL, UDDI

WS limitations

- However, WS still require human interaction
- Syntactic definitions do not completely describe the capability of a service
- Can't be understood by Sw programs
- Invocation can't be fully automated
- Human interaction required to
  - Discovery
  - Invocation
  - Interpretation
  - Combination

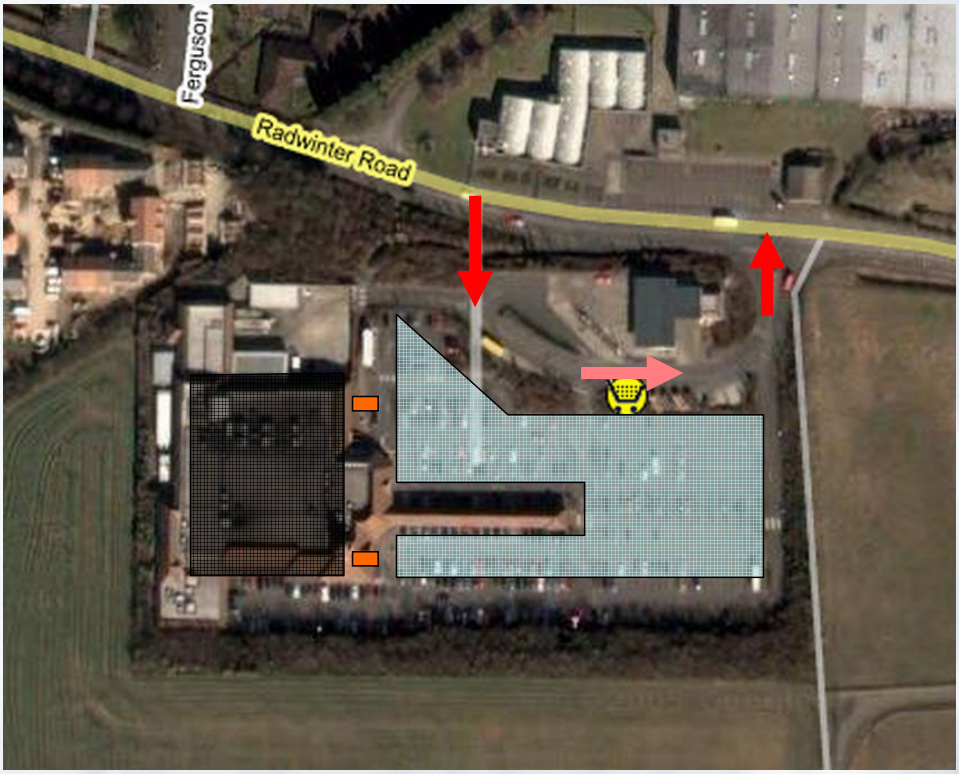
SWS technology

- Semantic mark-up of WS
  - Ontologies provide support for the semantic descriptions
- Better/quicker access to distributed data
- Allow creation of “ad hoc” services that meet the users’ interests
- Better position to understand what data sources are available
- Access to information at different levels of detail
- Perform queries based on semantic values
- Automatic discovery/invocation/mediation/combination of heterogeneous data sources

SWS technology

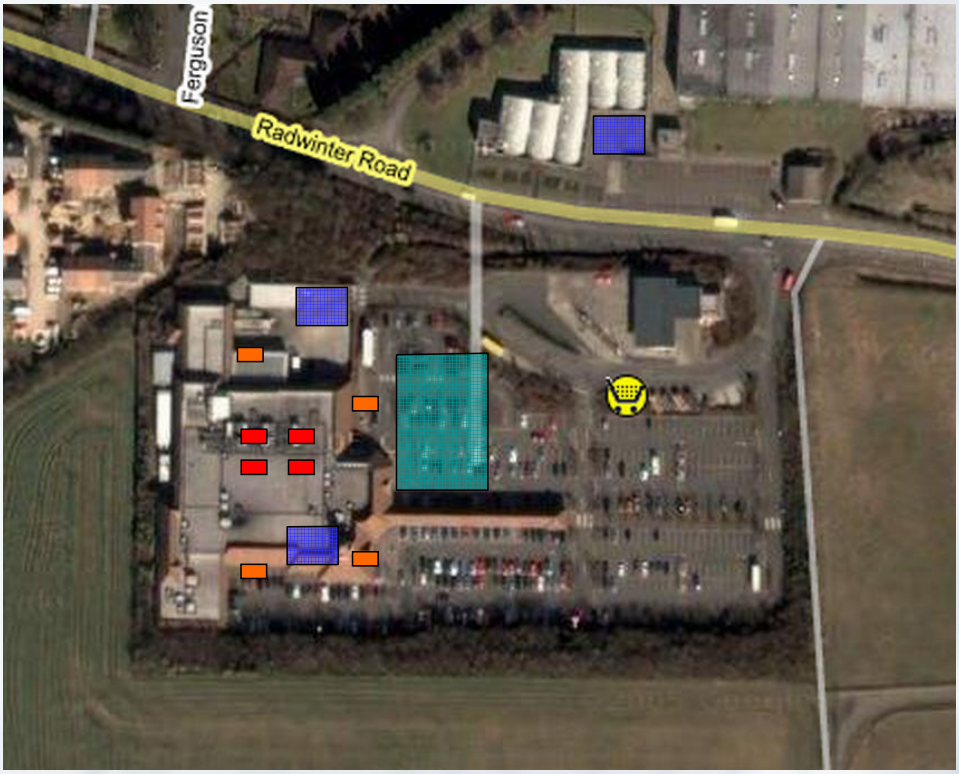
- Semantics allow to overcome heterogeneity issues
  - SWS mediate between heterogeneous data formats
  - SWS cope with heterogeneous service behaviour
- SWS can discover and compose service execution workflows based on semantic descriptions of services capabilities
- Complex services with multiple paths of execution and levels of process nesting
- Most suitable response seamlessly delivered to en-user in real time “**under a single click of a button**”
- Allow different access to information/views to different users

Police View



County Council EPOs View

Fire brigade View



Different Views

- Views can be created on the fly
- Views are accessible in real-time
- The user should be able to choose the views he has access to
- Ontologies to support different views

Scenario description

- Several interviews with involved (emergency-related) agencies:
  - Meteorological office
  - Ordnance Survey
  - Police
  - Fire
  - Ambulance services
  - ECC H&T (traffic control centre)
  - BAA (British Airport Authority)
  - Other county councils surrounding Essex (Hertfordshire, Cambridgeshire)

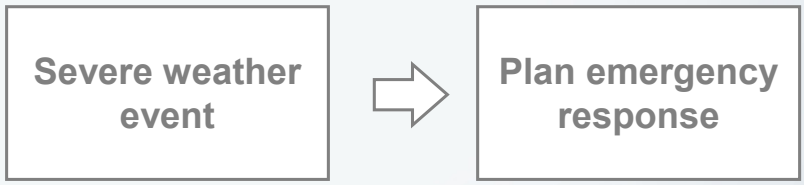
Scenario description

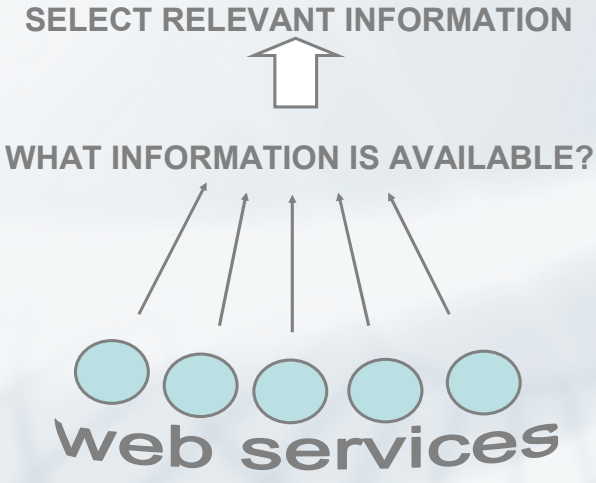
- Users' requirements gathered
  - R1: Inter-agency cooperation
    - Relevant data from many sources and many formats
    - Civil contingencies Act (2004): "Local responder bodies have to co-operate in preparing for and responding to emergencies through a Local Resilience Forum"
    - Also Essex Emergency Services Coordinating Group (Essex Police, Essex Fire and Rescue Services, British Transport Police, Essex Ambulance Services, Maritime Coastguard Agency, Military and Local Authorities)
  - R2: Predefined Emergency Procedures
    - Set out each agency's duties
  - R3: Geography Matters
    - GIS can ease the integration, storage, querying, analysis, modelling, reporting and mapping of geographically-referenced data relevant for the emergency situation
    - Locate hazards, vulnerable facilities and people, resources and supplies
  - R4: Cross- border relationships
    - Highly important, specially in Stansted area (not part of a local government district but its own territory)

Scenario description

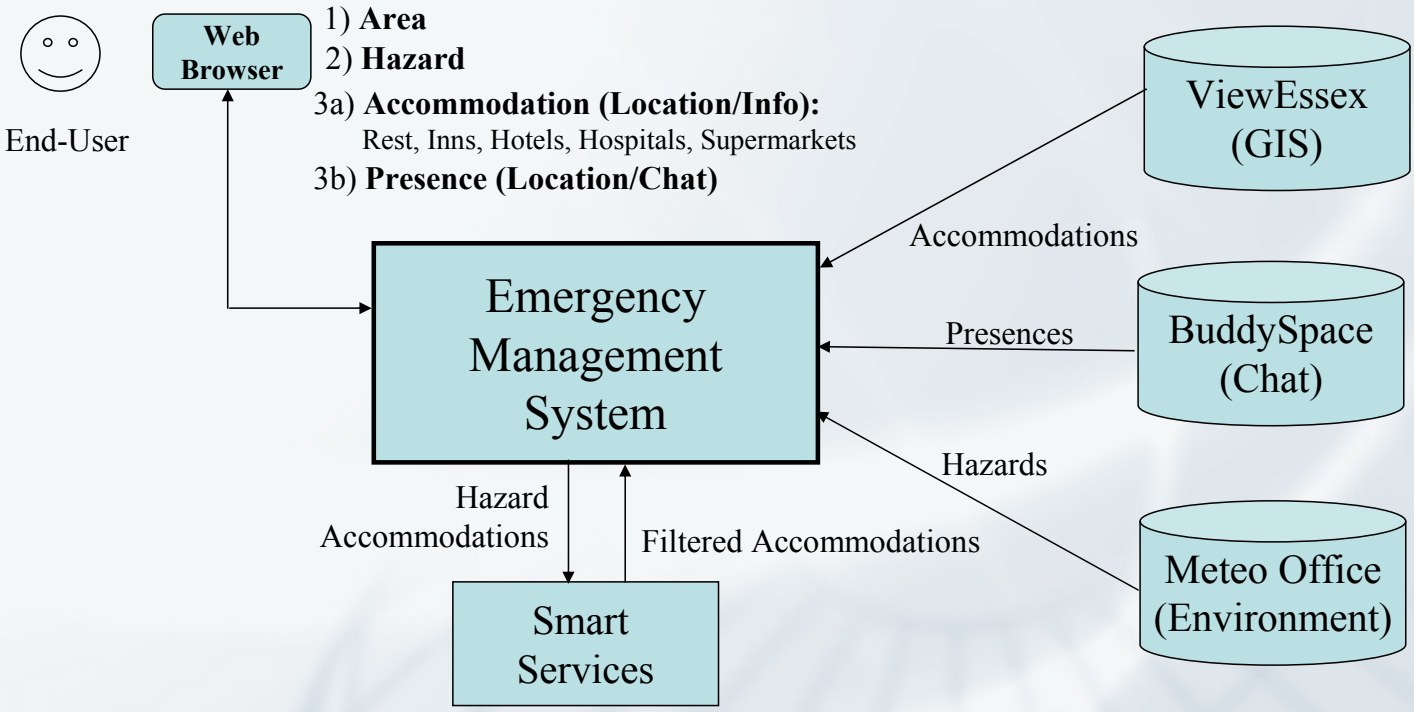
- Initial use case
  - Real past situation: *"Heavy snowstorm around the Stansted area and M11 corridor in Essex on 31st January 2003"*
    - *Assures the availability of real data*
    - *Compare data availability/actions taken at that time with the new data/processes available with the EMS*
  - Trapped overnight thousands of motorists
  - Stranded hundreds of people in Stansted airport

Scenario description

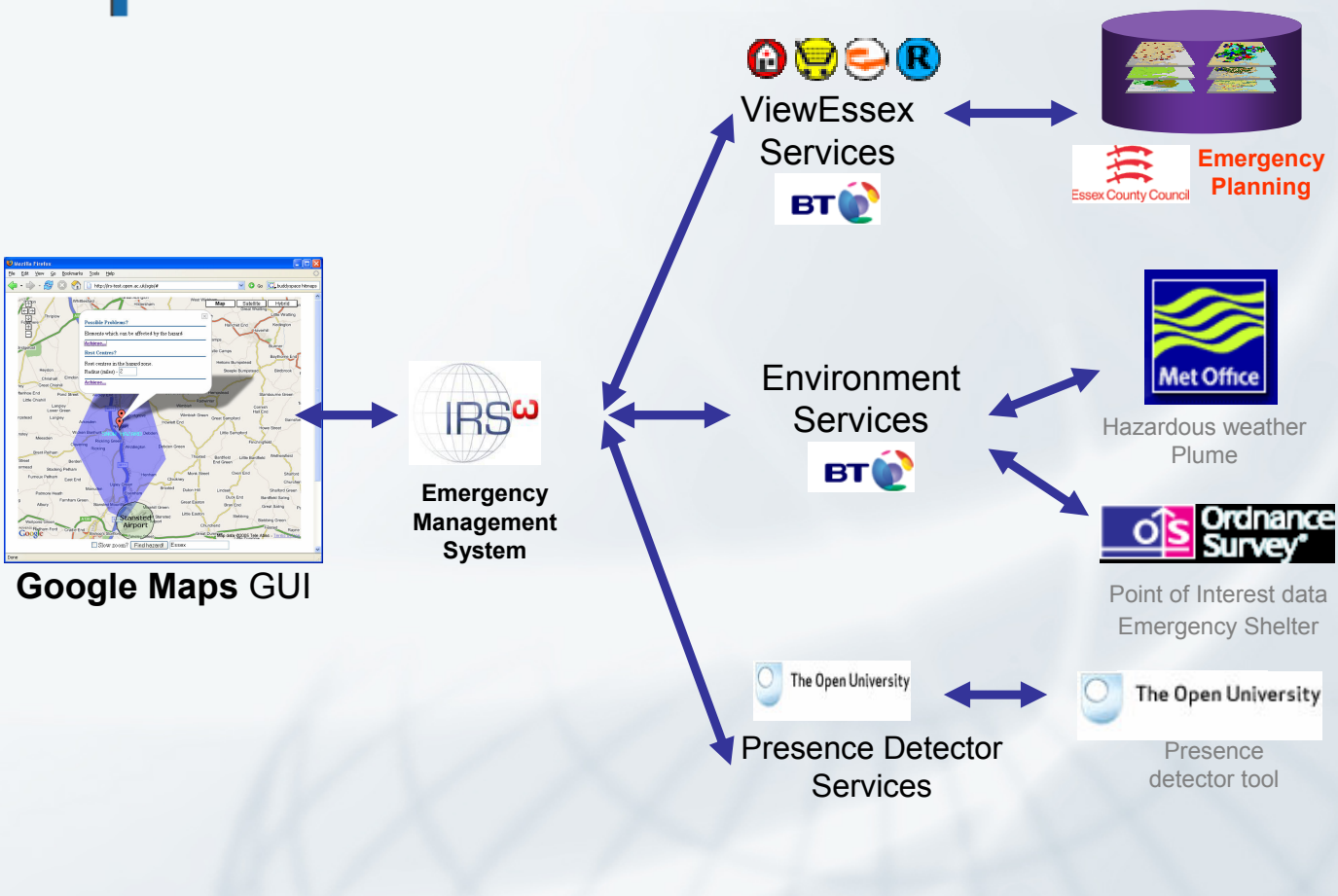




Structure of the Prototype



ECC Emergency planning Prototype



Architecture (four-layered SOA)

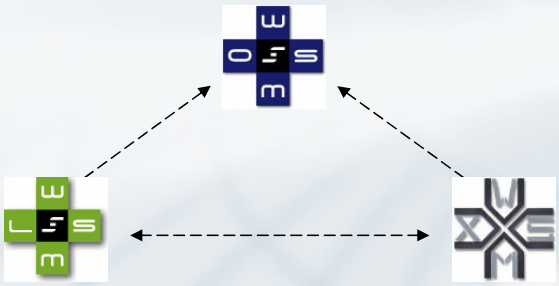
- Legacy system Layer
  - Existing data sources and IT systems of all parties
- Service abstraction layer
  - Exposes micro-functionalities of the legacy systems as WS abstracting from the Hw and Sw platforms.
- SWS layer (implemented in IRS-III)
  - Given a goal request:
    - Discover a candidate set of WS
    - Select the most appropriate
    - Mediate any mismatches at the data, ontological and business process level
    - Invoke the selected WSs
- Presentation layer
  - Web application accessible through a standard Web browser
  - Goals reflected in the interface – can be invoked through the IRS-III API or as an HTTP GET request
  - Goal requests are filled with data provided by the user and sent to the SWS layer
  - Goals supported by community related ontologies

Functionalities/Data

- Location of facilities
  - Supermarkets, rest centres, supplying companies, etc.
- Location of rescue corps and involved personnel
  - Buddy Space instant messaging
- Location of vulnerable people
  - Demographics and census data
- Plume forecast
  - Models of chemical release (CHEMET system) from Meteorological Office.
- Heat Wave
  - Heat Wave warnings from Meteorological Office
- Real-time traffic information
  - ECC H&T department
- Flooding
  - Environment agency
- Environmental Plan (ECC)
  - Pay special attention in case of plume scenario
  - Wildlife, listed buildings, industrial sites

SWS technolgy: WSMO

- WSMO is a **conceptual model** for SWS:
  - Ontology of core elements for SWS (WSMO)
  - Formal description language for WSMO and a rule-based language for SWS (WSML)
  - Execution environment (WSMX)



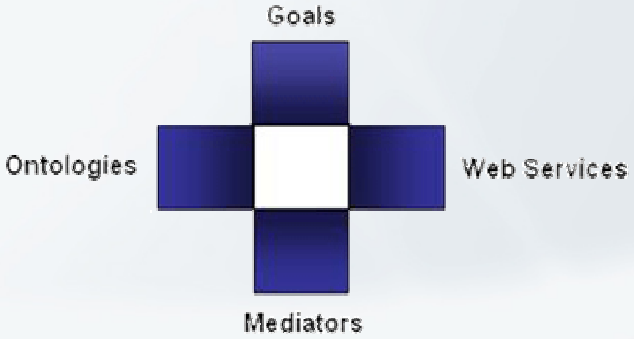
WSMO Design Principles

- Web Compliance
- Ontology-Based
- Strict Decoupling
- Centrality of Mediation
- Ontological Role Separation
- Description versus Implementation
- Execution Semantics

WSMO Top Level Notions

Objectives a client wants to achieve by using Web Services
Ontological De-coupling of Requester and Provider
Used mediators:
OO Mediators: Importing ontologies with heterogeneity resolution
GG Mediator: Goal definition by reusing an already existing goal
GW Mediator: Link goals and their correspondent WS

Formal terminology of the information used by all other components
Ontologies are used as the 'data model' throughout WSMO
All WSMO element descriptions rely on ontologies
All data interchanged in Web Service usage are ontologies, Semantic information processing & ontology reasoning



Semantic description of Web Services
Capability (functional)
Interfaces (usage)
Pre-conditions: What a web service expects in order to be able to provide its service. They define conditions over the input.
Assumptions: Conditions on the state of the world that has to hold before the Web Service can be executed
Post-conditions: describes the result of the Web Service in relation to the input, and conditions on it
Effects: Conditions on the state of the world that hold after execution of the Web Service (i.e. changes in the state of the world)

Connectors between components with mediation facilities for handling heterogeneities
Types of Mediation within Semantic Web Services:
OO: Ontology-Ontology mediation. Data mediation between different sources
WW: WS-WS mediation. Mediates between different WS to reach a more complex functionality. Used in choreography when combining different WS
WG: Web-Goal mediation. Link between the goal and the WS. A WS can't be invoke unless by means of a goal.
GG: Goal-Goal mediation. Refine or abstraction of existing Goals to create new ones.

IRS-III

- Platform which allows the description, publication and execution of SWS according to the WSMO conceptual model.
  - Invocation of WS via Goals as stated in the WSMO framework. (capability-driven service invocation)
    - User inputs only generic inputs, hiding the complexity of a chain of heterogeneous WS invocations
  - Ontologies are stored in the server, and used in WSMO descriptions to support discovery, composition, invocation and orchestration of WS.
- Based on a distributed architecture communicating via XML/SOAP messages provides an execution environment for SWS.
- Allows one-click publishing of standard WS which can be trivially integrated and described by using the platform.

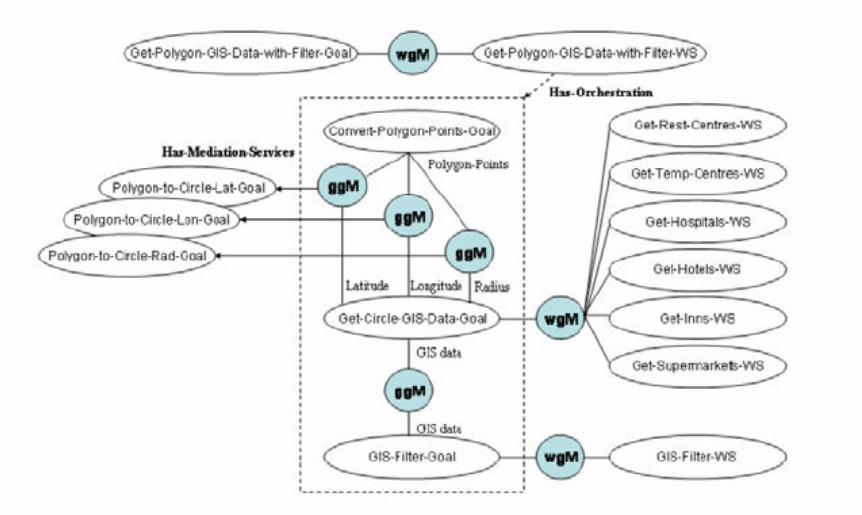
SWS description: Ontologies

- Ontologies defined to support WSMO descriptions
  - Domain ontologies, aggregation at a representation level ontologies, Aggregation at cognitive level, aggregation at spatial level, context ontologies.
- New source and the WS exposing its data and functionalities are integrated
  - New domain ontology is needed (can be reused)
  - Describe the services, data types and interface
- Lifting and Lowering operations
  - Passage of data types instances from a syntactic level (XML) to an ontological level (OCML, WSML) specified in the domain ontology definitions (lifting) and the other way around (lowering)
  - Lisp functions that automatically extract data from SOAP messages and create the counterpart class instances.
  - Mapping information between data types and ontological classes is defined at design time by developers

Domain Ontologies

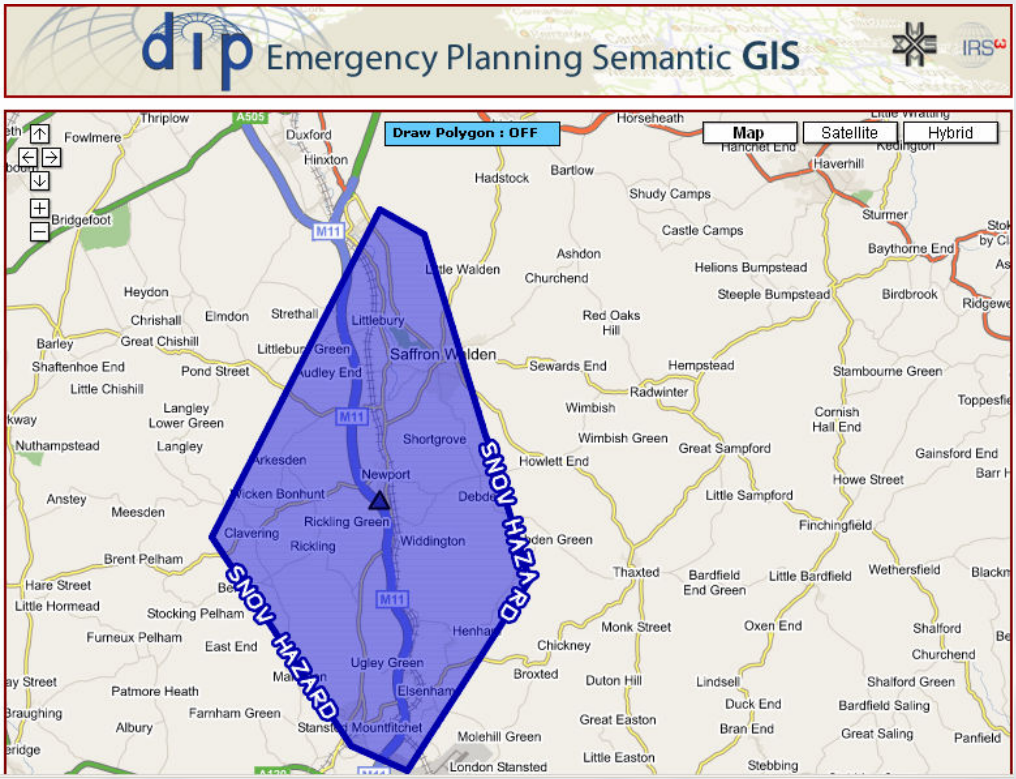
- Several ontologies being developed to support this scenario
  - Weather-related (closely collaborating with UK Meteorological Office)
    - Heat Wave ontology
    - Chemical Release (plume) ontology
    - Hazardous weather (snow) ontology
    - Flooding ontology (future)
  - Emergency planning related ontologies (closely working with ECC emergency planners)
    - General “GIS” ontology
    - Emergency-related ontology
    - Emergency shelter, hospitals ontology
    - Demographic related ontology (ongoing work)
    - Emergency suppliers, supermarkets related ontology
    - Traffic-related ontology (future work)
  - OS-related ontologies
    - PointX-related ontology (ongoing work)
    - Emergency-shelter related ontology (ongoing work)
  - Communications-related ontologies
    - BuddySpace ontology

SWS WSMO descriptions



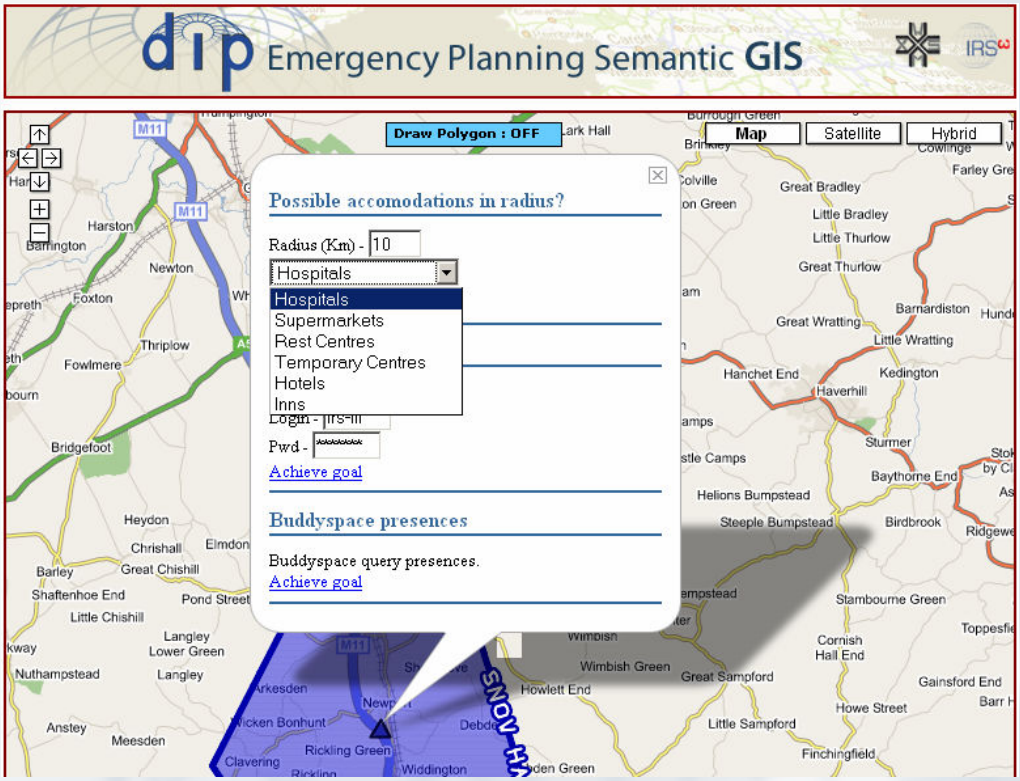
- Goal: Locate suitable shelters for evacuated people
- Discovery
- Selection
- Orchestration
- Mediation

Emergency Prototype



Emergency Prototype

Essex County Council



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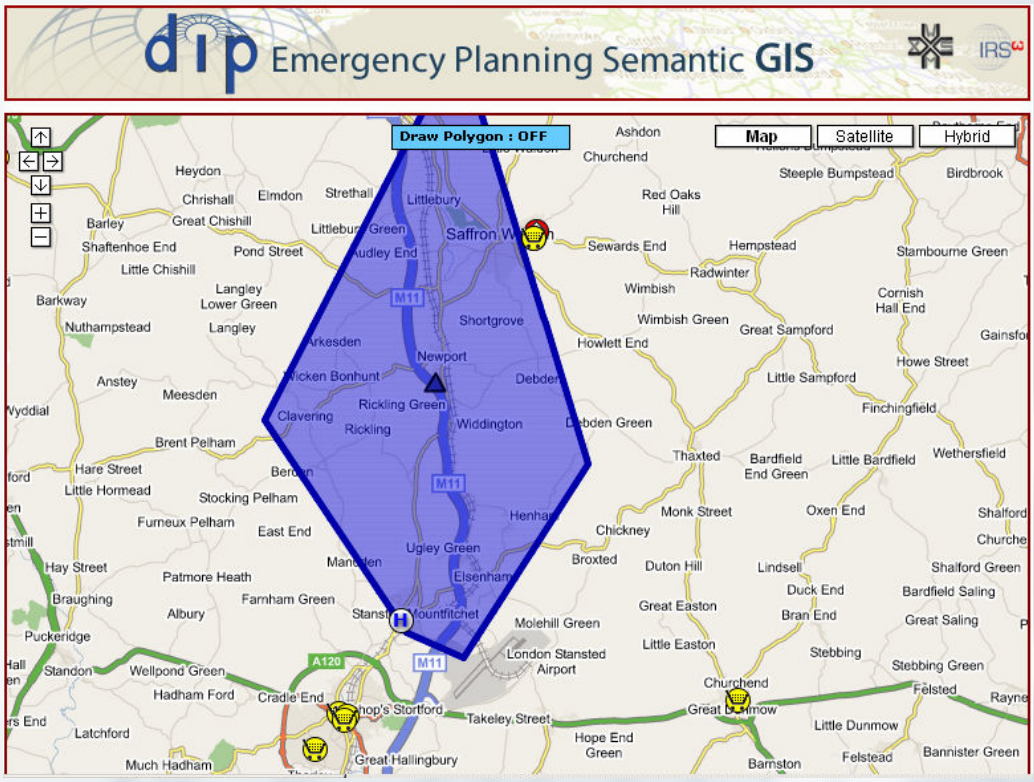

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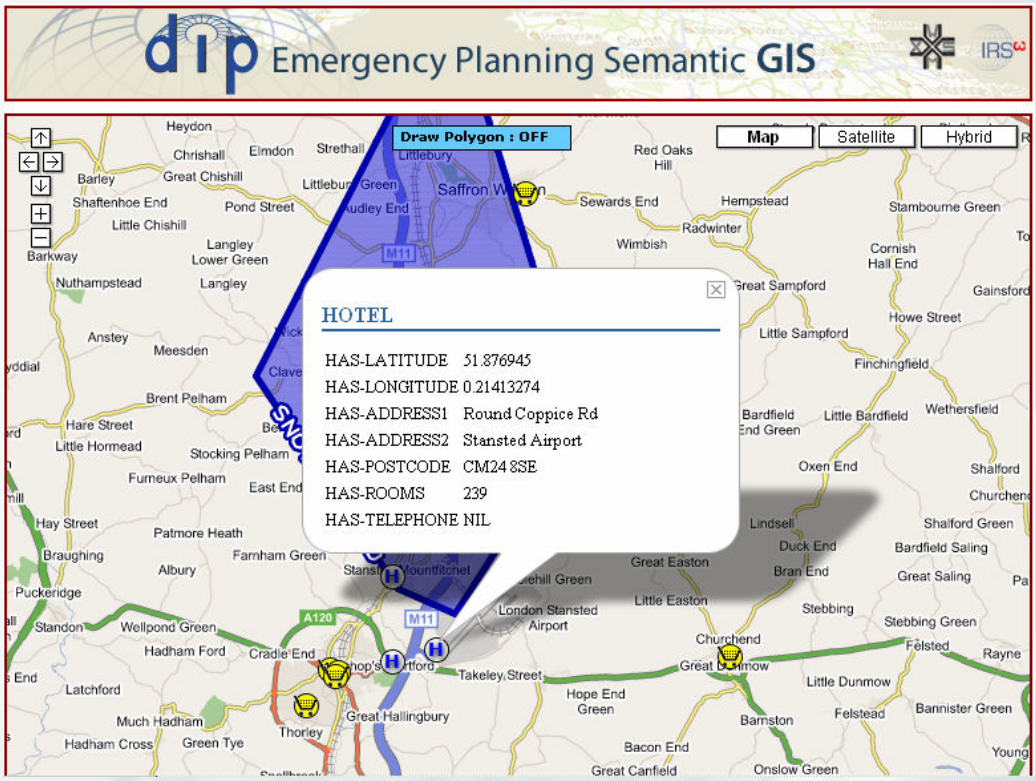

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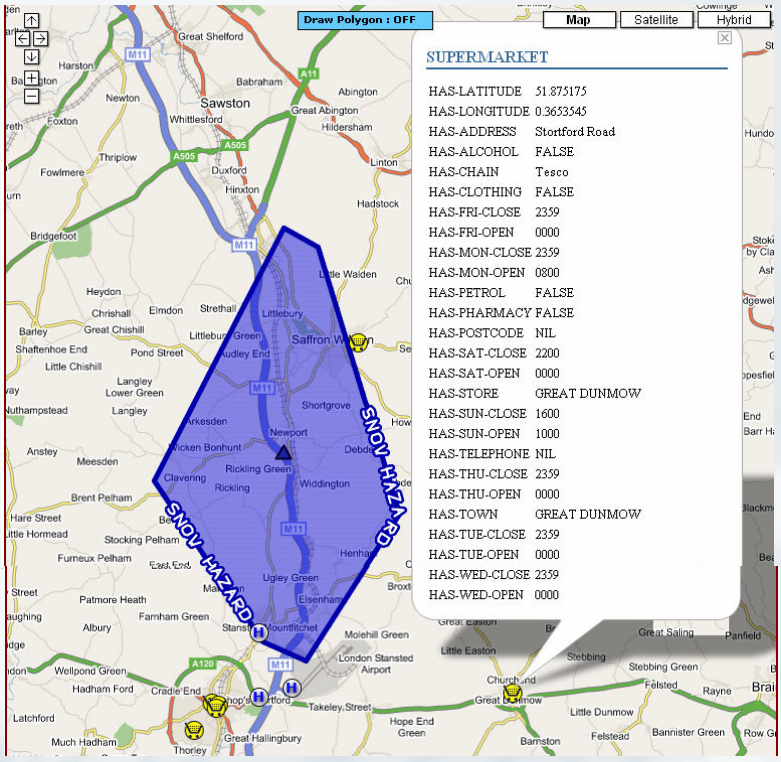

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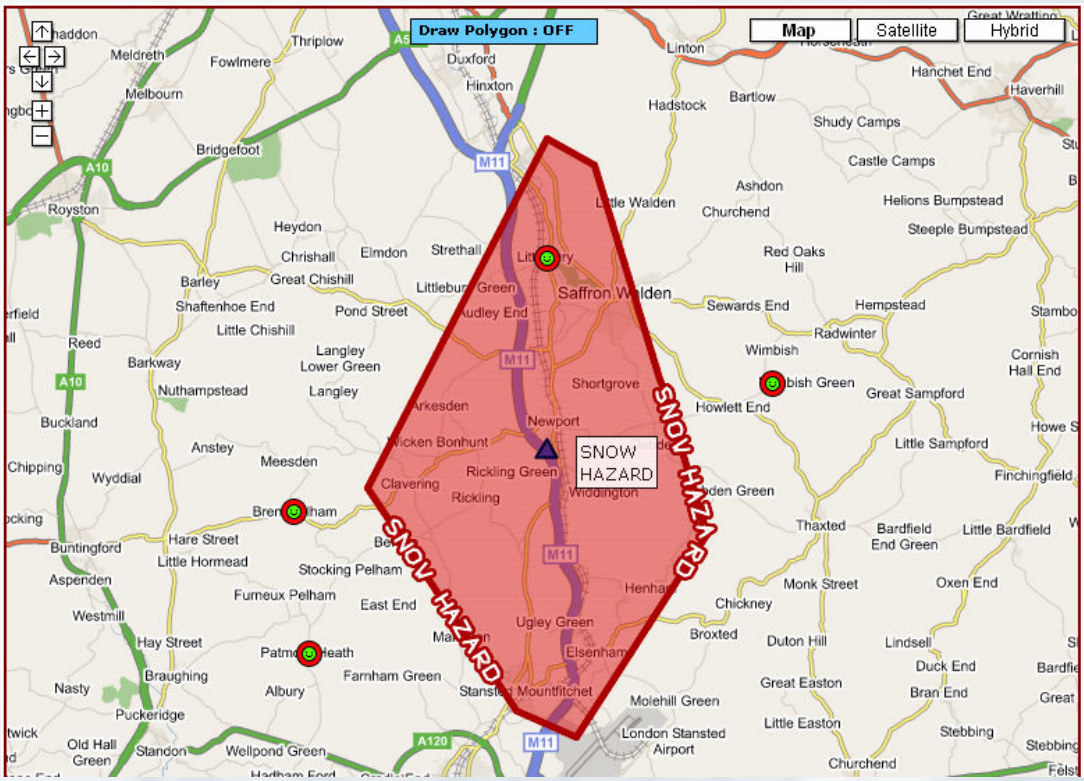

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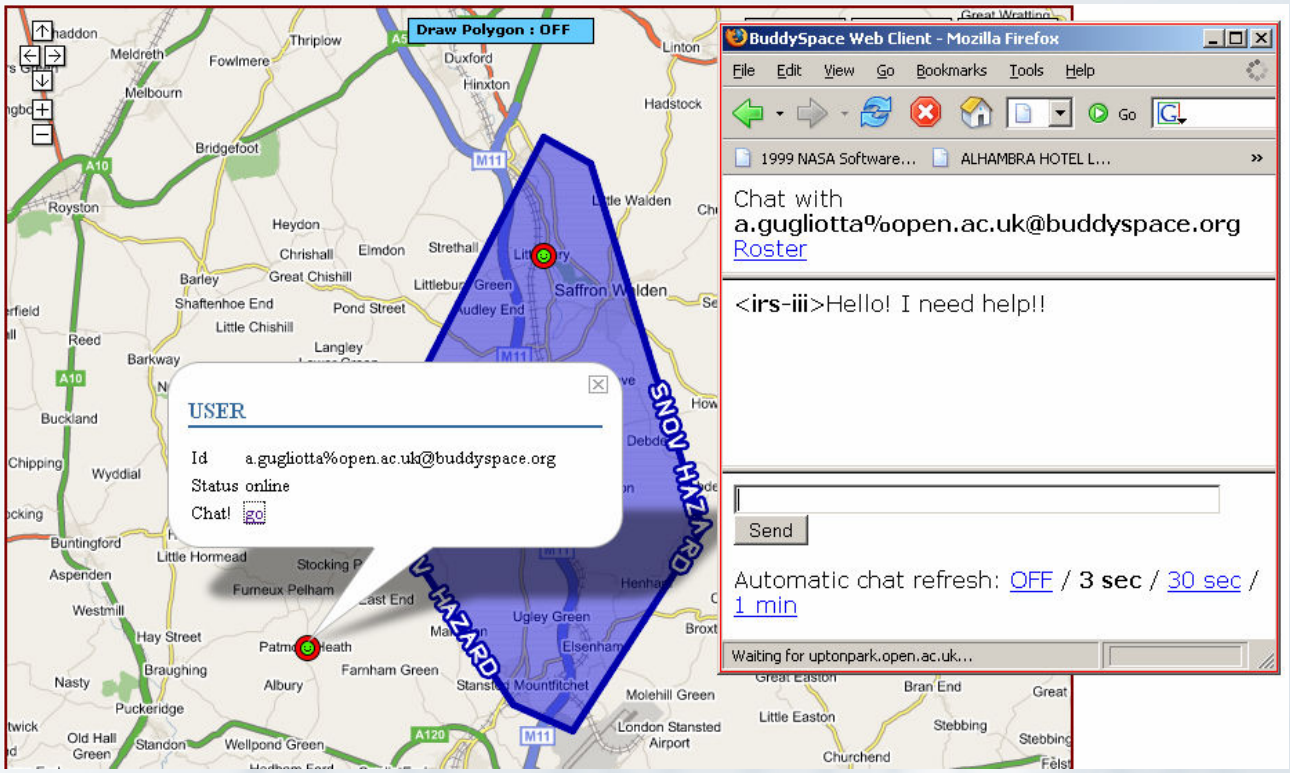

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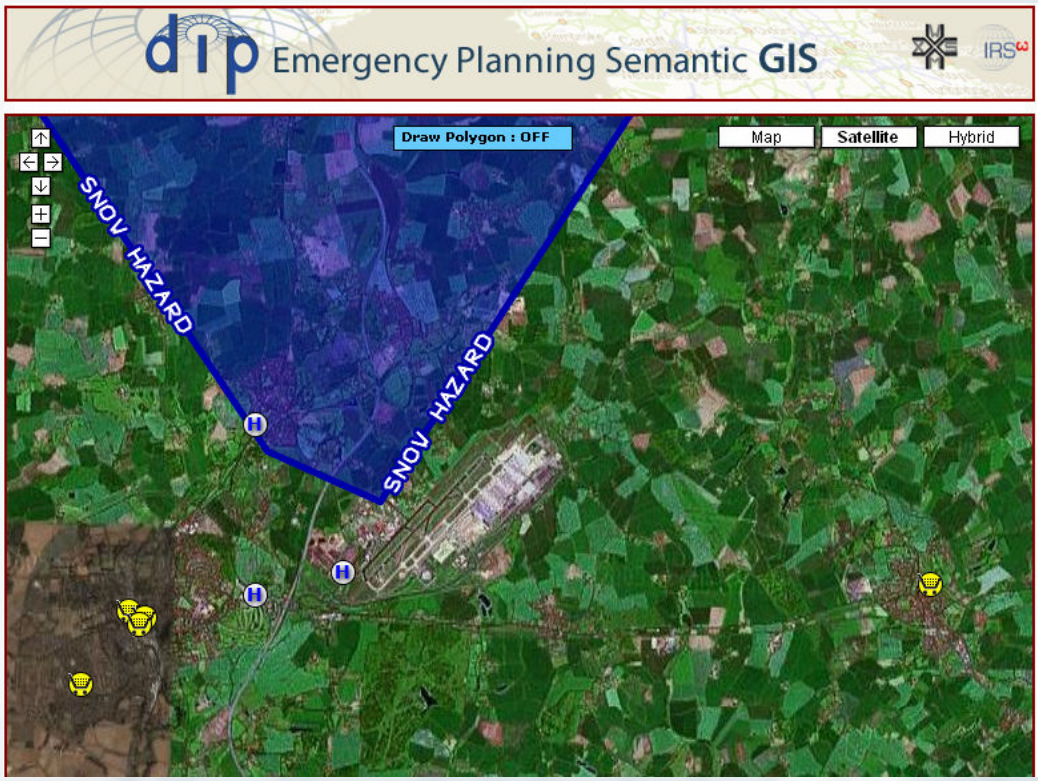

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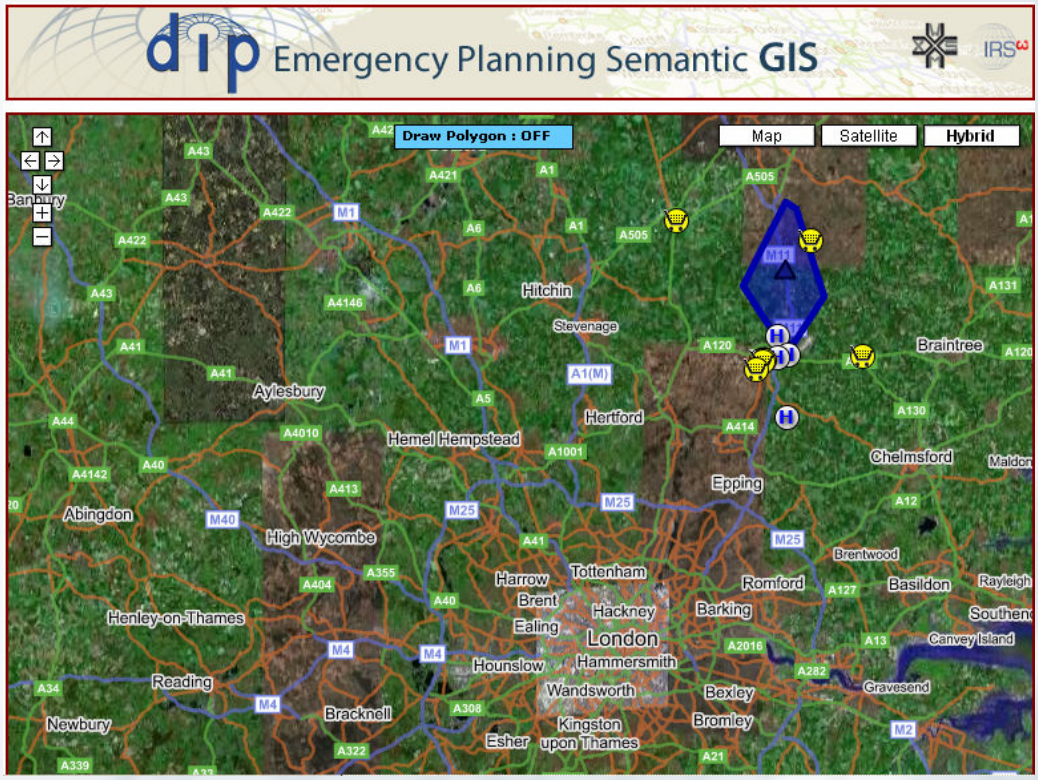


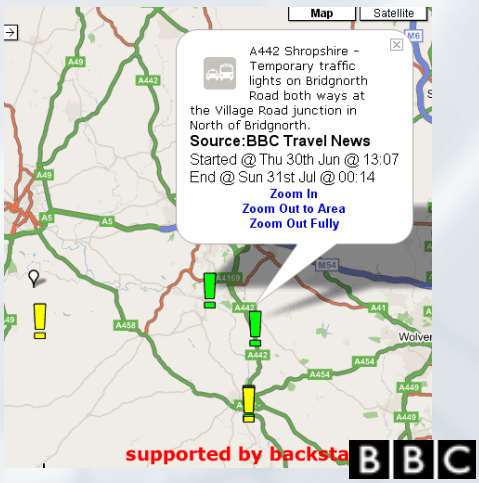
Future actions: Reasoning

- Schools occupancy
  - Evacuate casualties to closer school unless school occupied (if school term and school time)
- Choose the best supermarket to get supplies from
  - depending in the evacuees profile (babies, elderly, special food needs, …), the time and date (chose the ones currently open), their location (spatial-coordinates) and the supermarket products.
- Select the most suitable rest centres
  - Facilities
    - Telephone, toilets, heating, running water,…
  - Opening/occupancy hours
  - Location with regard to:
    - Area affected by hazard
    - Transport links (accessibility)
    - Utilities around (supermarkets, hospitals,…)
  - Suitability regarding kinds of evacuees
    - Accessible centres for elderly and disabled people
    - Suitable facilities for babies, injured people, pregnant women, etc.

Future actions:Traffic and Rail data

- Traffic data
  - Current conditions
    - Current events and accidents
    - Delays: locked roads, traffic jams …
    - Roadworks
    - Roadside message signs
  - Future conditions
    - Future events
    - Future roadworks

- Rail and underground data
  - Current conditions
    - Delays, accidents
  - Future conditions
    - timetables, planned engineering works …
- Several traffic data providers identified
  - ECC/ BBC/ Traffic England (Highways agency), etc.
  - Automatic discovery and selection
    - Chose the best data provider (QoS) based on the users' preferences



Future actions: ECC travel information

- Car Park Guidance
  - Allows the public to see what spaces are available in each town centre car park
- Count Detectors/Scoot Loops
  - Journey Time information: can see if traffic is flowing at a normal rate for the time of day or is congested
- TRIPS (Travel Real-time Information and Priority System)
  - real-time passenger information and bus priority system: real-time information about bus departures and provides late running buses.

Future actions: Resources companies/suppliers

- Survival blanks, survival bags, survival foil…
- Hypothermia blankets
- Food supplies: Hot cans, hot beverages
- Portable heating, cooling, drying devices
- Water purifiers, decontamination kits/products, water pumps.
- Portable kitchens, toilets
- Emergency clothing, footwear
- Emergency beds
- Flood protection

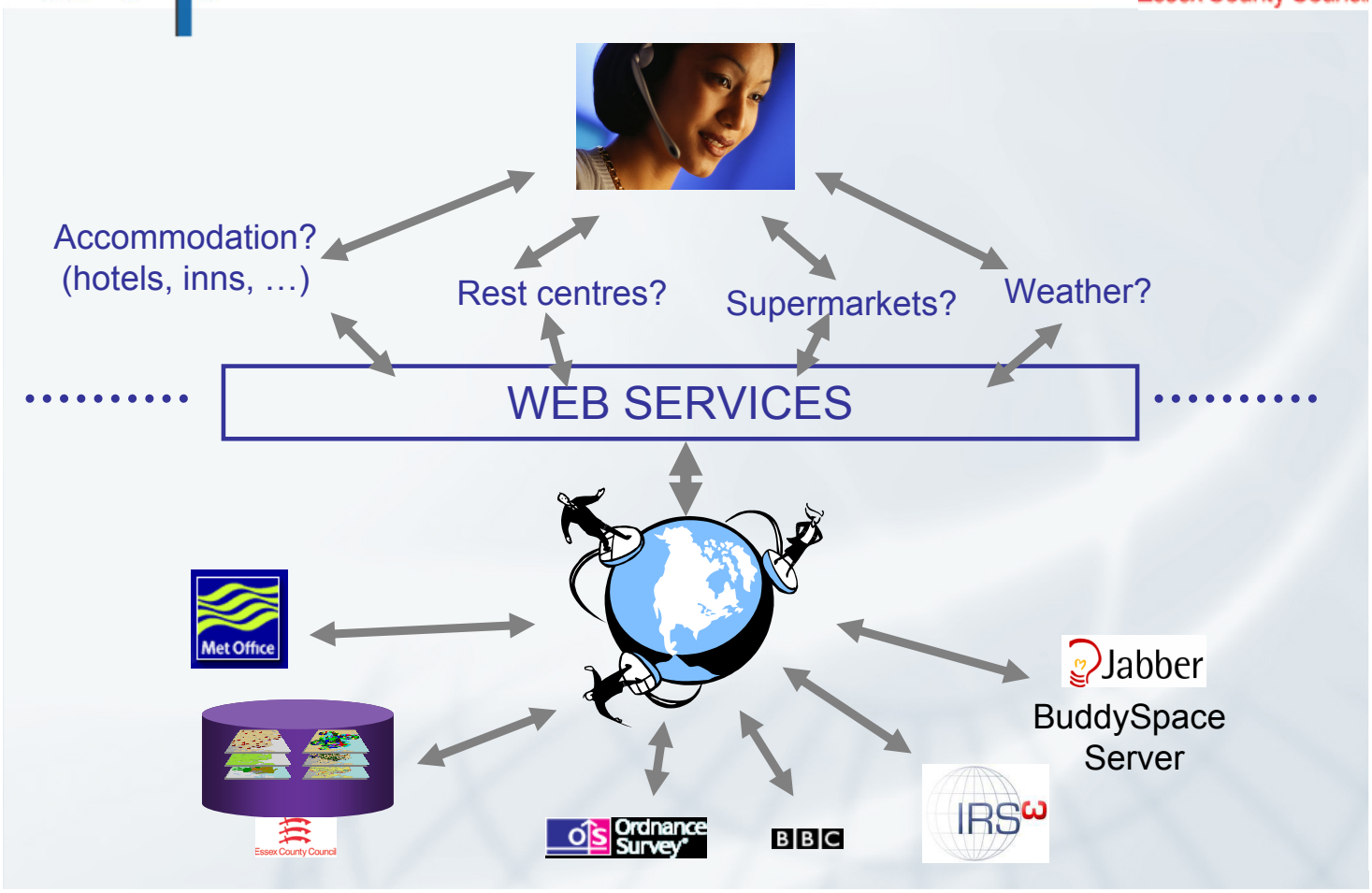
Conclusions

- Supporting all the phases of emergency management
  - Before
    - To gather information before the emergency
      - Emergency prevention, preparation and planning.
  - During
    - To instantly access real-time information during the emergency situation
      - Plan the response.
  - After
    - To gather data in the aftermath (some data could have changed after the issue)
      - Carry out recovery phase.
    - To analyze the situation once the case is closed
      - Reporting and 'lessons learned'.

Online Demo

http://irs-test.open.ac.uk/sgis-dev/

User's perspective



Data, Information and Process Integration with Semantic Web Services