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Letting the Cucumber Speak: Smart Agriculture, Semantic Food and the Challenge of Knowledge Technologies

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Outline

- The SmartAgriFood project
- The technologies
- The users
- Semantic Food
- Models and Ethics

Data - Information - Knowledge

- The food supply chain involves hundred of actors, thousands of processes, millions of products and billions of data points!
- Children believe milk comes from supermarkets!
- Too much or too little data?

Data - Information - Knowledge - 2

- E. Coli epidemic:
  - The past 2 weeks have seen 20+ deaths, 2000+ infections
  - Spanish cucumbers **wrongly** accused of being the source. Organic cucumbers!
  - €200M losses are claimed by Spain.
- What is the data that was missing?
- Why can we not ask the cucumber?

The Project

The Big Picture: Future Internet

- EC is funding big multi-year multi-project programme: **Future Internet Public Private Partnership**
- to advance Europe's competitiveness in Future Internet technologies
- to support the emergence of Future Internet-enhanced applications of public and social relevance

Smart Agri-Food

SmartAgriFood Project

- Presents food and agriculture as a **use case** for the Future Internet:
  - What are the special requirements in food production, food logistics, and food consumption?
  - How must the Future Internet adapt to be fit for future agriculture and food sector of the economy and society?
  - How can efficiency be increased and environmental impact reduced?

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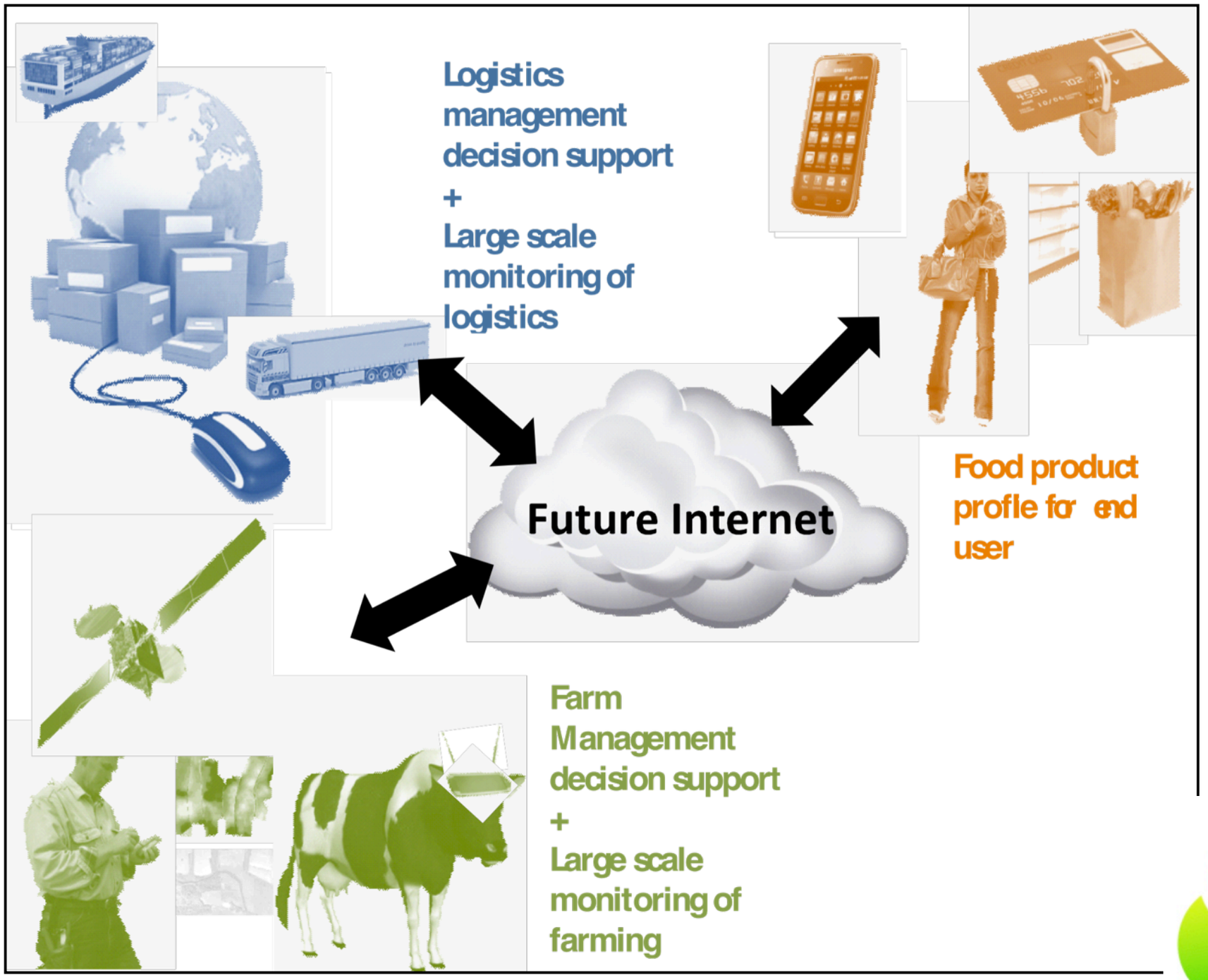
SmartAgriFood Project

€7.3M budget - 21 Partners - across 7 countries

Stichting Dienst Landbouwkundig Onderzoek	Netherlands
Institut für Angewandte Systemtechnik Bremen GmbH	Germany
Nederlandse organisatie voor toegepast-natuurwetenschappelijk onderzoek	Netherlands
CentMa GmbH	Germany
ATOS ORIGIN SOCIEDAD ANONIMA ESPANOLA	Spain
Ariadna Servicios Informáticos S.L.	Spain
Huawei Technologies Düsseldorf GmbH	Germany
Maa- ja elintarviketalouden tutkimuskeskus (MTT Agrifood Research)	Finland
Kuratorium für Technik und Bauwesen in der Landwirtschaft e.V.	Germany
National and Kapodistrian University of Athens	Greece
Universidad Politécnica de Madrid	Spain
Campden BRI Magyarország Nonprofit Kft.	Hungary
Aston University	United Kingdom
VTT Technical Research Centre	Finland
Payment and Control Agency for Guidance and Guarantee Community Aids	Greece
Deere & Company	Germany
Wageningen University	Netherlands
EHI Retail Institute GmbH	Germany
GS1 Germany GmbH	Germany
SGS International Certification Services Ibérica, S.A.	Spain
Bon preo Supermarkets	Spain



Agri-food presents unique challenges to FI and ICT technologies!

Smart Agri-Food

SmartAgriFood Project: Specific Objectives

- Focus on three sub areas:
  - **Smart farming**, individual treatment of animals, plants or areas of land using sensing & monitoring, decision support and precise application to improve efficiency, productivity, quality, flexibility and chain responsiveness
  - **Smart logistics,** intelligent matching demand and sourcing followed by smart transport and logistics of agri-food products
  - **Smart Food Awareness,** enabling the consumer with relevant information e.g. concerning safety, availability, health, environmental protection, animal welfare, methods of production (organic, fair trade, halal, kosher, etc.)

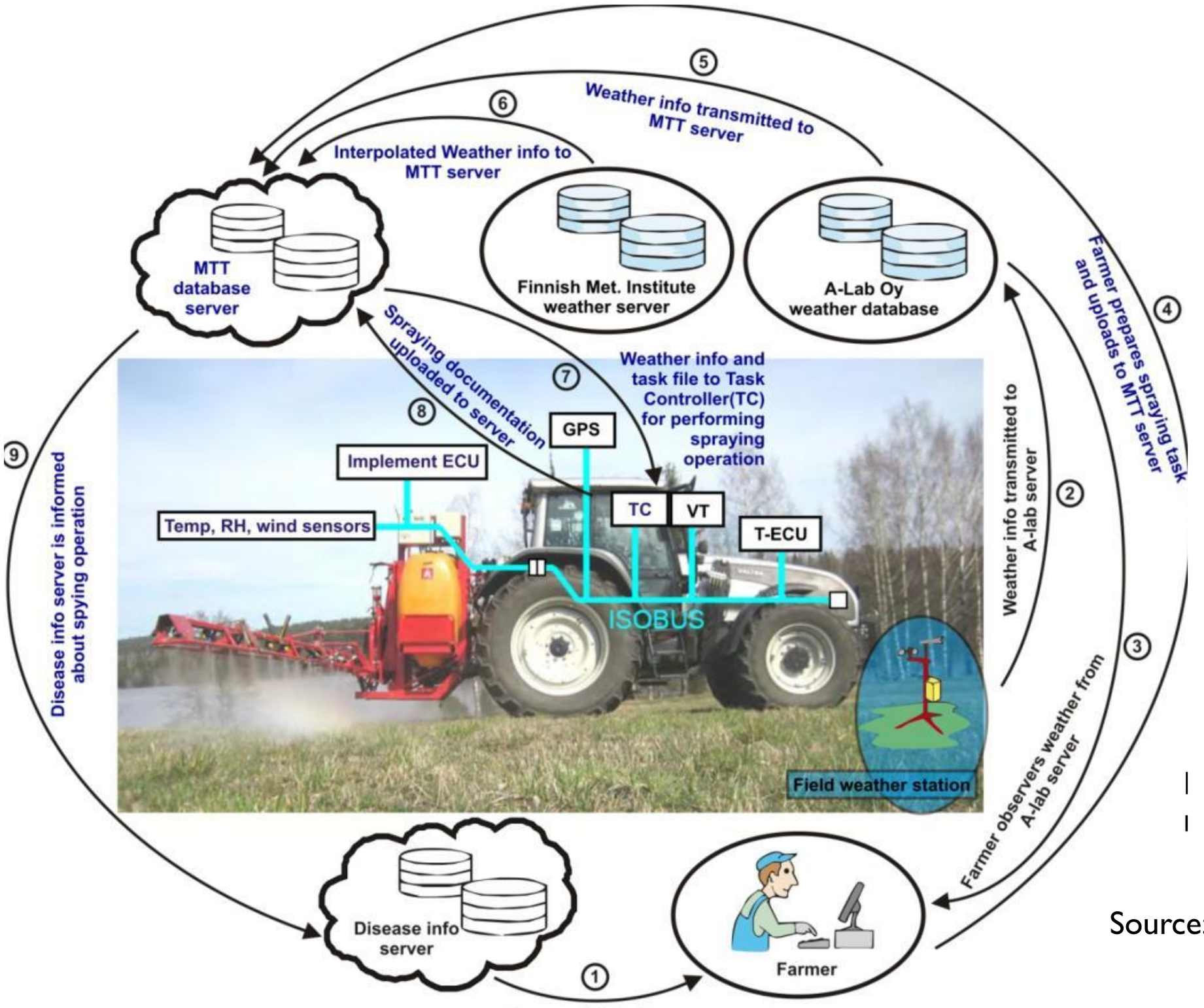
The Technologies

The Technologies - Future Internet

- The Internet is the nervous system of modern industrial society
- Future Internet is a stack of technologies:
  - hardware: high throughput architecture, communication networks (mobile and wireless, optical), sensors, etc.
  - software: image and video search engines, data mining, etc.
  - services: data processing, storage, “cloud services”, etc.
  - objects: Internet of Things - all objects addressable and interconnected
  - standards: protocols, ontologies, vocabularies, data exchange formats

Technologies for the Farm

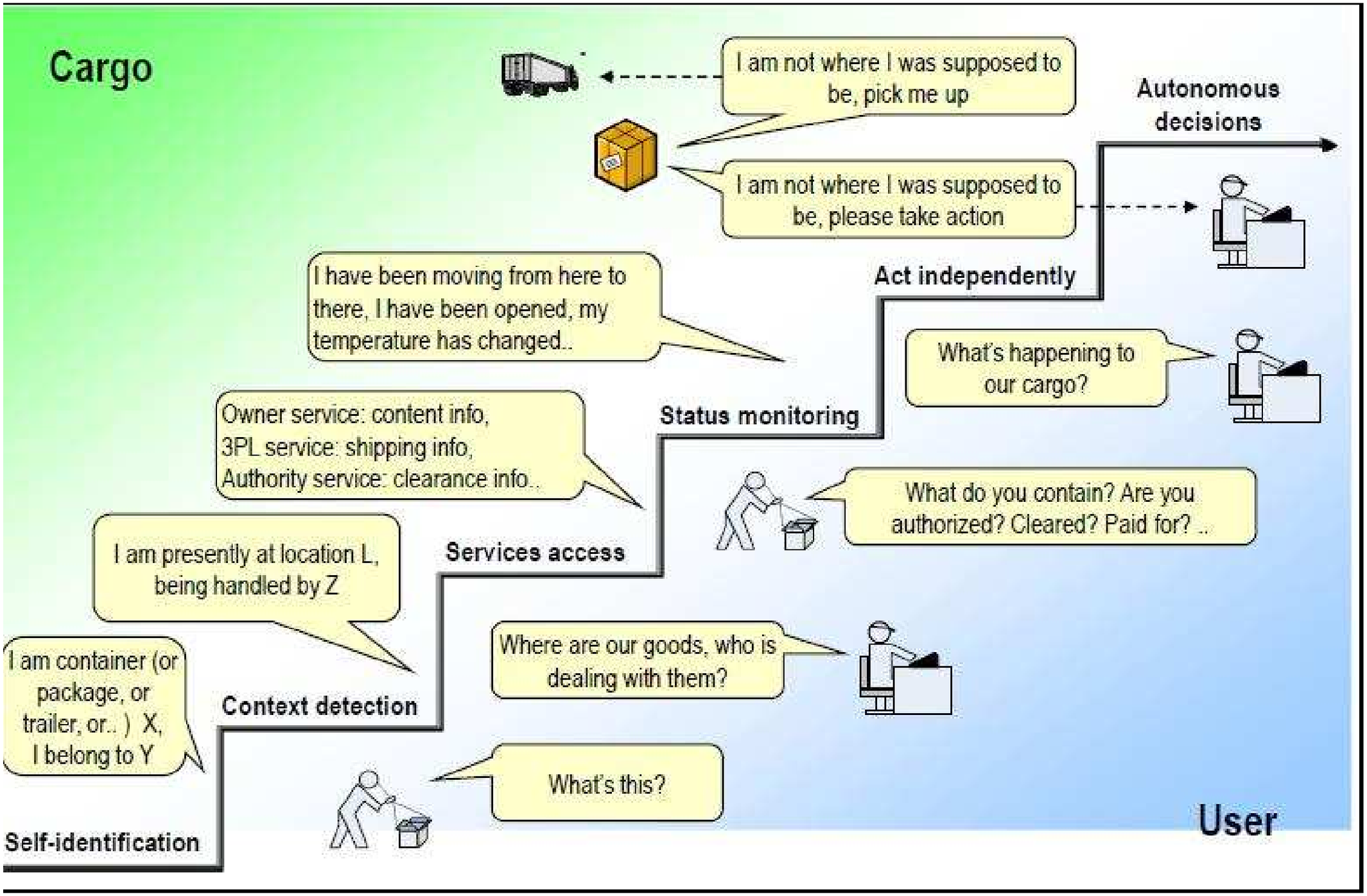
- Precision farming - about individual treatment of animals, plants or areas of land
- Key technologies: **Sensors (soil, air, plant, animal), GPS, satellite data (image, radar, infrared), meteorological data, mobile technology for wide areas**
- In order to:
  - Monitor and control crop/animal development
  - Provide decision support/ forecasting and warning
  - Provide traceability
- Challenge: fragmented existing technologies, lack os use of latest technological developments


5
Weather info transmitted to MTT server
6
Interpolated Weather info to MTT server
MTT database server
Finnish Met. Institute weather server
A-Lab Oy weather database
4
Farmer prepares spraying task and uploads to MTT server
Spraying documentation uploaded to server
7
Weather info and task file to Task Controller(TC) for performing spraying operation
8
GPS
Implement ECU
Temp, RH, wind sensors
TC
VT
T-ECU
ISOBUS
Field weather station
9
Disease info server is informed about spying operation
2
Weather info transmitted to A-lab server
3
Farmer observers weather from A-lab server
Disease info server
1
Farmer

Source: MTT

Technologies for Logistics

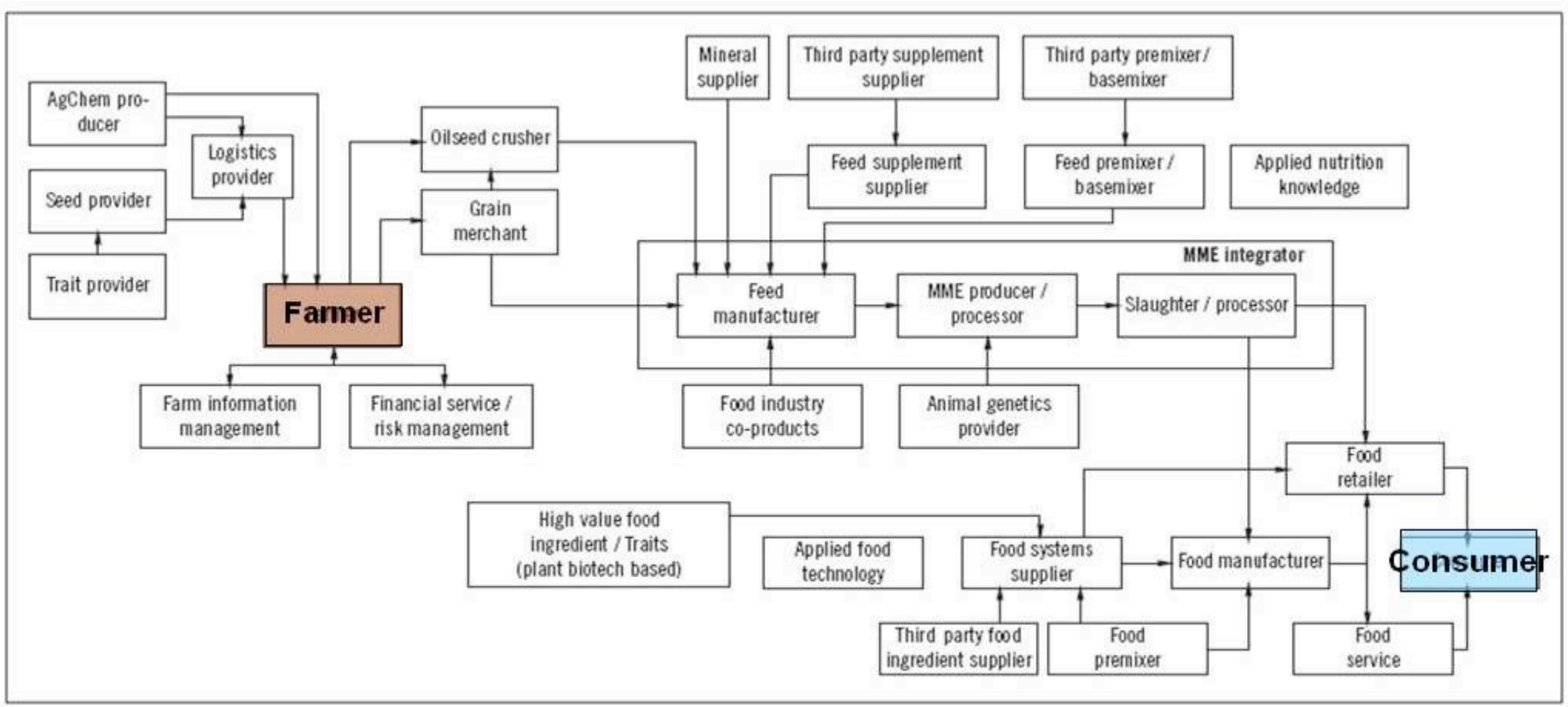
- Key technologies: auto-identification, conditioned transport using sensors and control systems, remotely controlled early warning systems, GPS
- Key challenges: responding to dynamic supply and demand, transparency, reducing environmental impact
- Increasing use of “servitisation” means technology is going in place anyway
- Other Challenges: high fragmentation, centralised database models, absence of trust between multiple actors, inter-enterprise systems absent



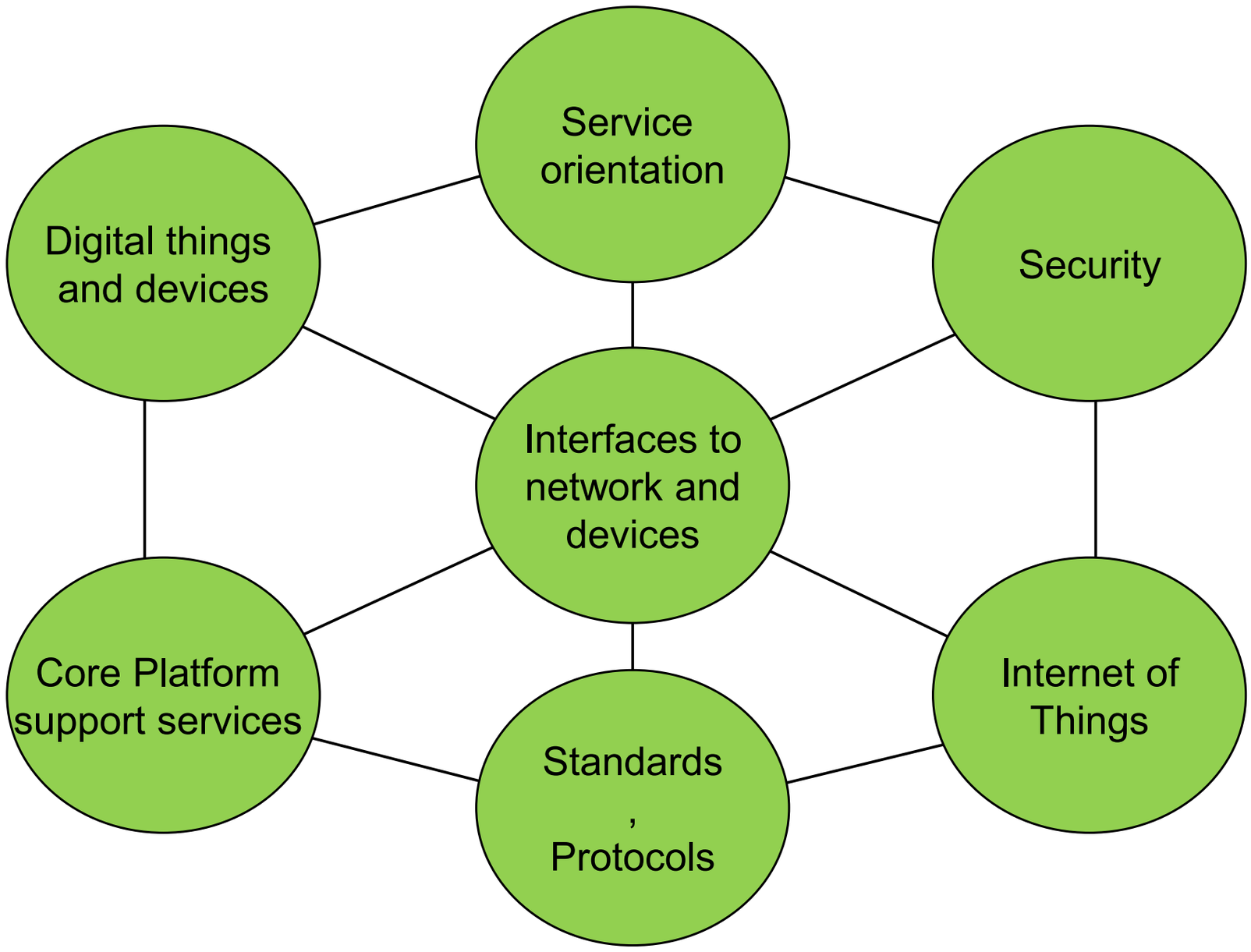
Paganelli, P. (2009). The Intelligent Cargo Concept in the European Project EURIDICE. 2nd European Conference on ICT for Transport Logistics. Venice

Technologies for Food Awareness

- Key technologies: smartphones, other interfaces and handheld devices, consumer services, data mining, information integration
- Key challenges: Social and cultural - making information available, releasing the data to a wider public, trust and provenance - why should one trust a particular source?
- Current status: No dedicated personalised systems provide food data to consumers (some experiments)
- Huge potential for smartphone apps!


AgChem pro-ducer
Logistics provider
Seed provider
Trait provider
Farmer
Farm information management
Financial service / risk management
Oilseed crusher
Grain merchant
Mineral supplier
Third party supplement supplier
Third party premixer / basemixer
Feed supplement supplier
Feed premixer / basemixer
Applied nutrition knowledge
MME integrator
Feed manufacturer
MME producer / processor
Slaughter / processor
Food industry co-products
Animal genetics provider
Food retailer
High value food ingredient / Traits (plant biotech based)
Applied food technology
Food systems supplier
Food manufacturer
Consumer
Third party food ingredient supplier
Food premixer
Food service

Another perspective



Source: Robert Reiche & Richard Lehmann,University of Bonn

State of ICT in agri-food sector

“Large amounts of available data, poor level of integration and insufficient support for intelligent use of these data”

.... and an obsession with centralised systems, a lack of openness and trust

The Users

Users and User Requirements

- Key objective of SmartAgriFood - user driven requirements
- User requirements obtained by a combination of interviews, questionnaires and scenario generation
- Food and agriculture supply chain a complex set of actors!
- Who are the users?

Conventional Users

- Farming: farmers, suppliers, purchasers
- Logistics: transporters, drivers, managers
- Food awareness (consumer end): retailers, caterers, customers, different managers

Unconventional Users/Stakeholders

- Farming: the soil, the crops (the individual cucumber), the domesticated animals, the wider ecological context (flora and fauna)
- Logistics: the individual cucumber (again), the truck, the packet of goods
- Food awareness: the cucumber (again)

Only the cucumber is a constant actor!

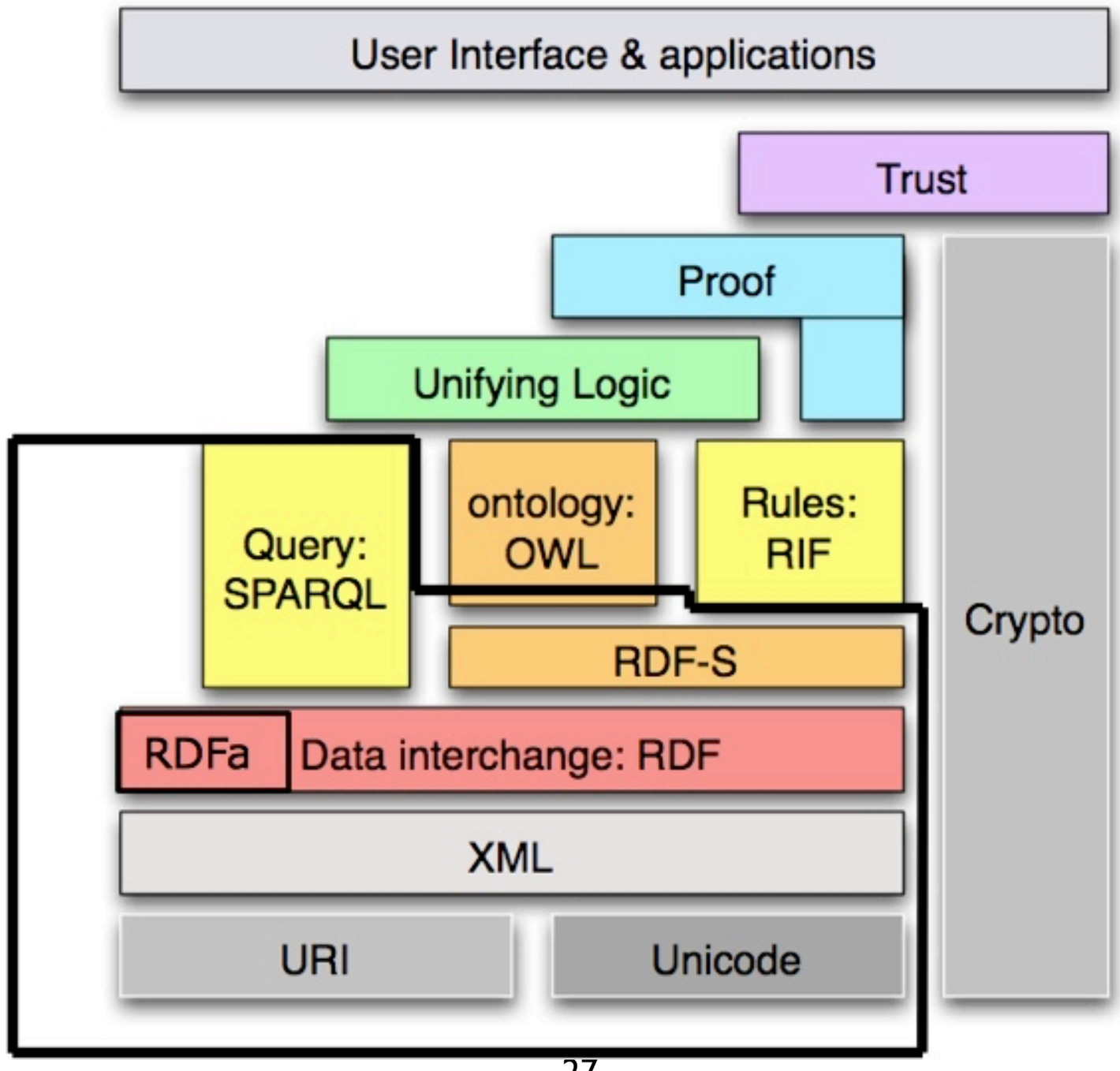
Semantic Food

Semantic Web Technologies

- A stack of technologies led by Tim Berners-Lee and the W3C
- Objective: to move from a “Web of Documents” to a “Web of Data”
- Explicitly linking data across the World Wide Web in a machine readable formats
- Consists of a stack of **open standards**.
- Major growth over past ten years
- Otherwise known as: Web of Data, Giant Global Graph, Data Web, Web 3.0, Linked Data Web, Semantic Data Web, Enterprise Information Web

The SW Layer Cake

Actively being used



What is the point?

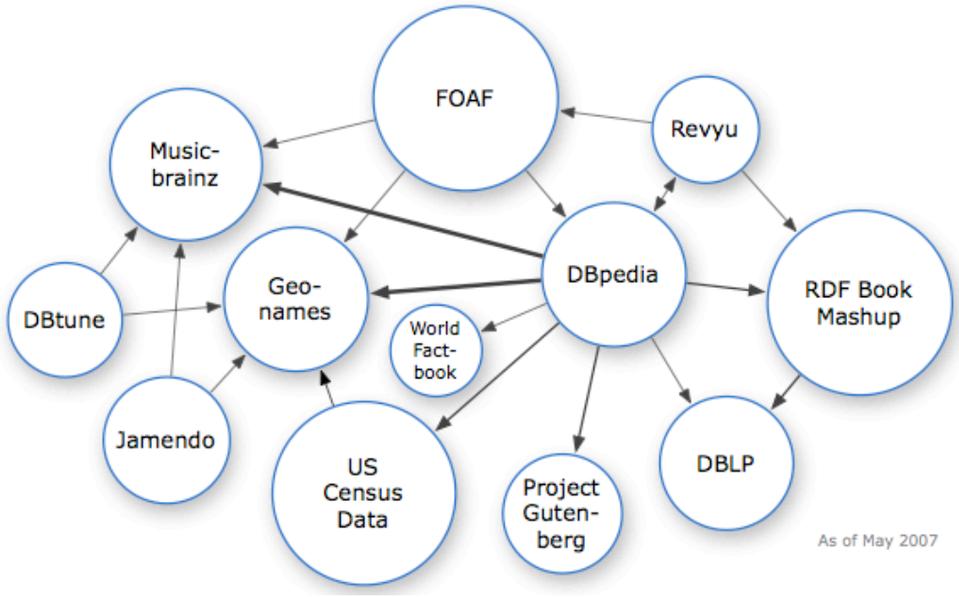
- A family of technology standards that ‘play nice together’, which provide:
  - a flexible data model
  - an expressive ontology/schema/formal vocabulary language
  - and a distributed query language
- Used For:
  - Data integration
  - Business intelligence
  - Semantic Search

Source: Lee Feigenbaum: Evolution Towards Web 3.0:The Semantic Web

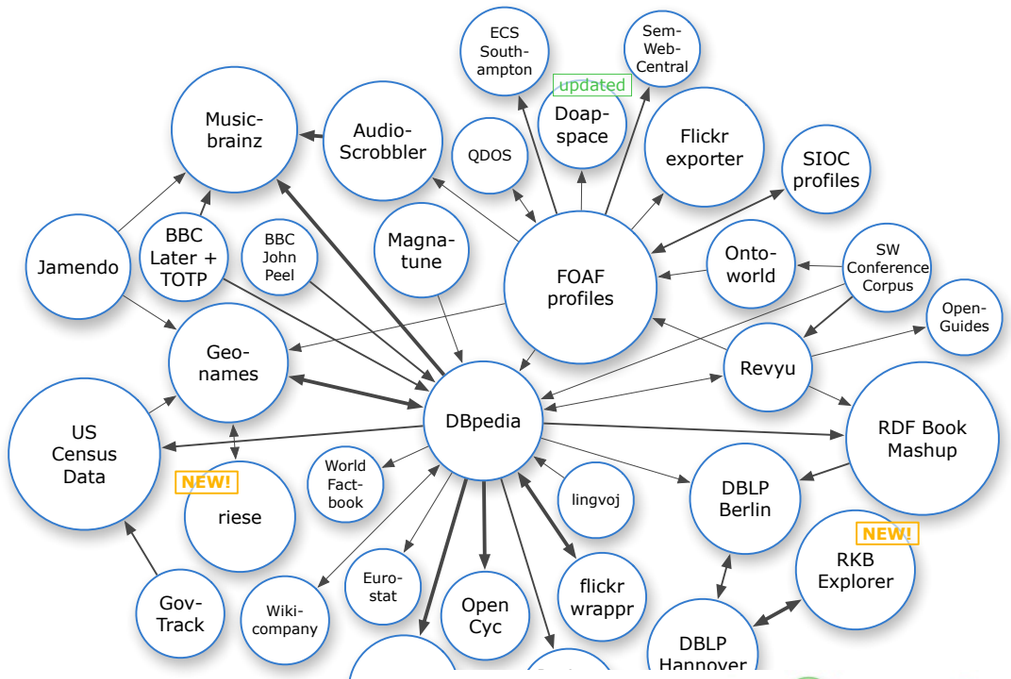
Current Users of Semantic Technologies

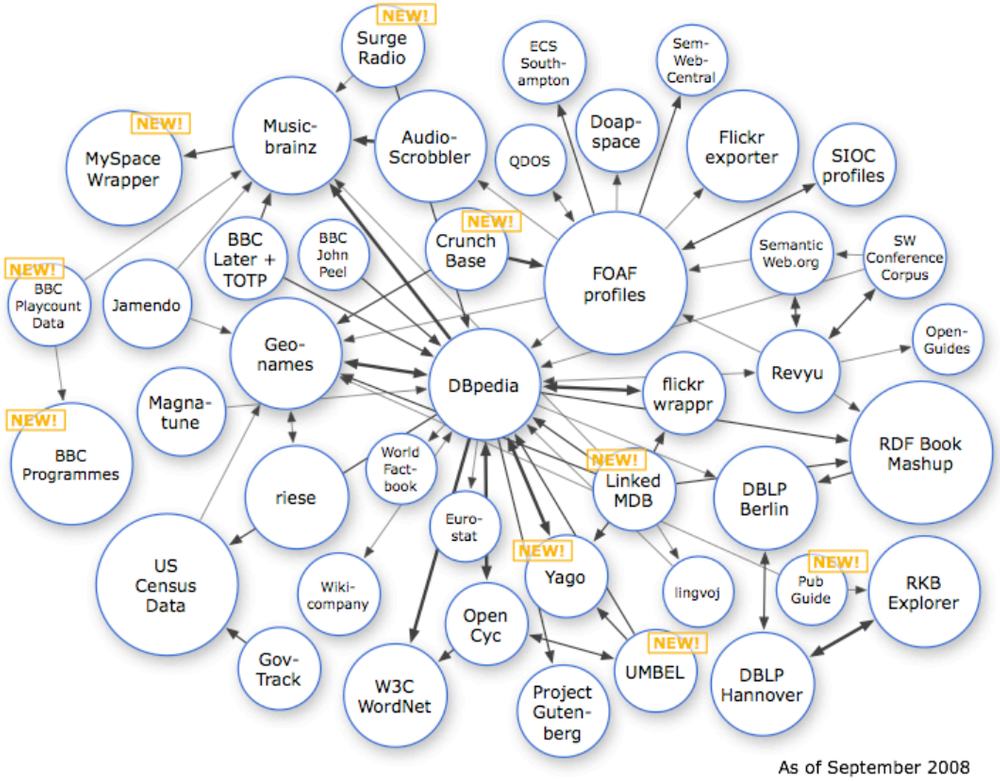
- Search engines (Google, Yahoo, Bing) in 'rich snippets':
  - Best Buy is using the Good Relations ontology (http://www.heppnetz.de/projects/goodrelations/) for markup:
    - 30% increase in web traffic
    - 15% in click through for ads
- Life Sciences:
  - AstraZeneca are integrating 20+ databases of biomedical research, 5B statements
  - Integrating multiple datasets to answer complex queries: "What genes are involved in signal transduction and are related to pyramidal neurons? Reduce search from 220,000 possibilities to 32 results.
- NASA, Garlik.com, and many others

The Growth of Linked Data



As of May 2007





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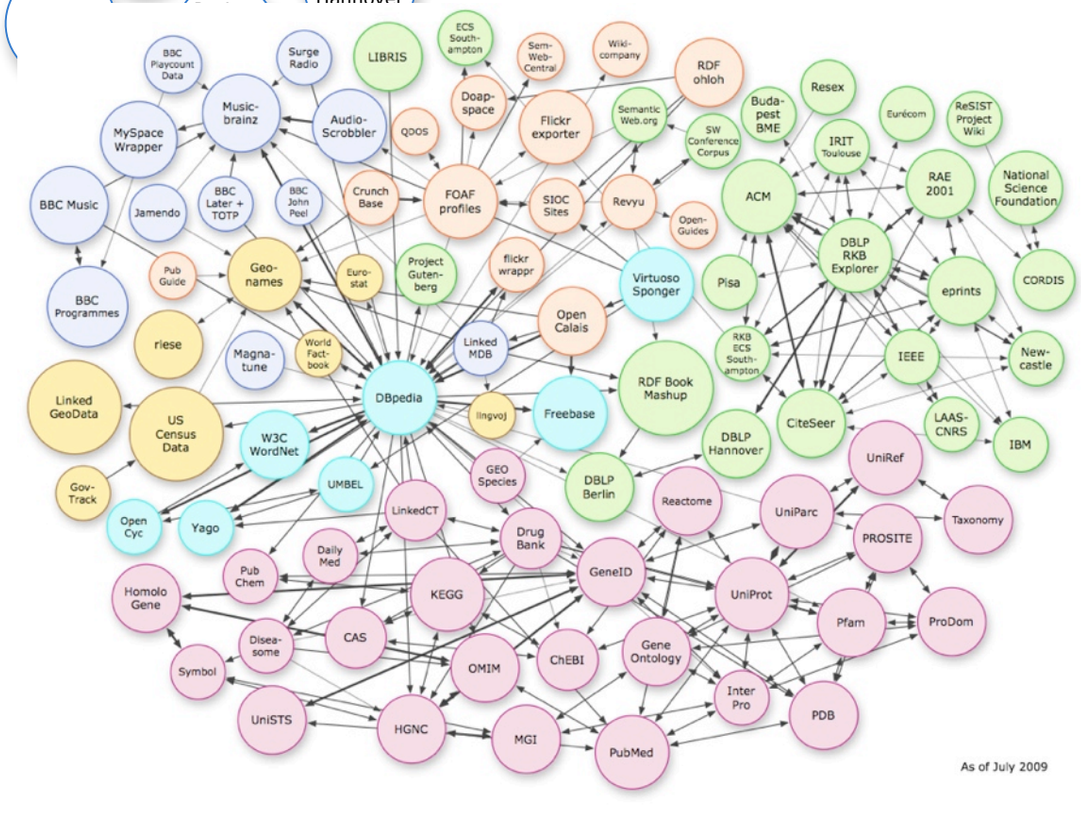

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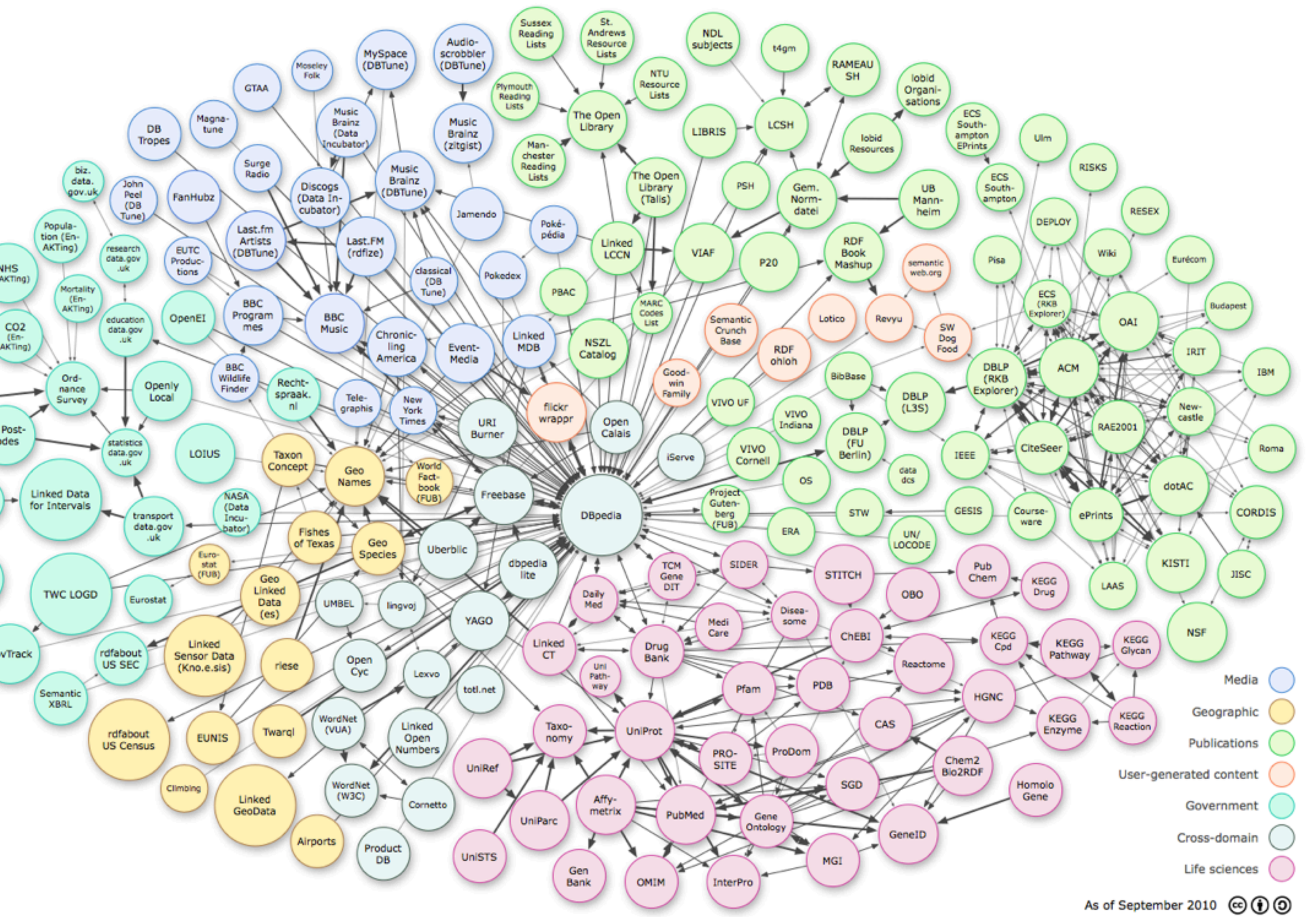

Linking Open Data cloud diagram, by Richard Cyganiak and Anja Jentzsch. http://lod-cloud.net/

Where is the food?

- Food and agriculture is conspicuous in its **absence!**
- There **are** relevant technologies in existence (mostly by FAO):
  - Agrovoc (in OWL/SKOS) http://aims.fao.org/website/Linked-Open-Data/
  - Fisheries Ontologies
  - many links to other vocabularies and ontologies undertaken or planned (GEMET, NALT, AgroXML ...)
- But .... cultural, social, economic factors are still hindering uptake
- A great deal of re-invention of the wheel is occurring.

Agri-food Supply Chain Data

- Even now:
- Huge amounts of data captured but in **Silos** (i.e. separate isolated databases)
  - Farmers
  - Logistics
  - Retails
  - Consumers/Eaters
- ... all generate data in various ways but it is not joined up, we cannot query it across space, time, actors, sectors

Semantic Technologies and Big Data

- Agri-Food is Big Data scenario
  - Thousands of actors
  - Millions of individual products
  - Billions of data points
- SW now is handing very big data e.g. LarKC project (http://www.larkc.eu/) allows very large scale knowledge processing

Cucumbers and E. Coli

1. Which cucumbers did persons P_0 ....P_n buy, which retailers, where did the retailers obtain them from, what logistics chain did each cucumber follow, which farm did they originate from .....?
2. and what were the growing conditions?
3. and who do P_0 ... P_n have personal contact with?

The data is there, somewhere, out there!

Can we bring together?

The Data is there, somewhere ...

- Person P_0 ... P_n are the victims (hospital records)
- Purchases (bank cards --> retailers --> receipts --> time/location of purchase)
- Cucumber source (retailer purchasing/ordering datasets)
- Journey of cucumber (truck and logistics data + sensors)
- Original farm (based on truck collection, puchase/ sales receipts)
- Circle of contacts of P_0 ... P_n (social media, Facebook, Twitter, phone records)

Models and Ethics

The problem with Models

- All ICT, smart farming, semantic technologies, depend on models of the world
- Human being tend to believe the models (rather than the evidence, their senses, their experience)
- **“All models are wrong, some are useful”** George Box 1987

Knowledge Loss and Gain

- Farming is a complex process
  - Observation
  - Experience
    - Tacit and explicit knowledge
    - Multidimensional data inputs (visual, sensual, historical)
- No matter how good, some knowledge will be lost in the expansion to Smart Farming
  - Many examples from other fields e.g. Flaming 2003 on Nursing

Knowledge Loss and Gain - 2

- On the consumer end:
  - Majority of consumers suffer from extreme ignorance of food production
  - Children think milk comes from supermarkets
  - **So** more transparency, more food awareness, more access to knowledge can only be a good thing

Social Opportunities

- to connect farmers to eaters
- to connect eaters to the sources of their food
- to connect people who share common food and agricultural interests
  - connect farmers at a local level
  - connect connect eaters to each other
- enable every actor along the food supply chain to feed data/queries into the network

Business Opportunities

- Allowing farmers to ‘know’ their end consumers
- Enabling better planning, faster response to changing demand
- Reducing waste through the supply chain
- .... many unforeseeable opportunities

The Ethical Challenge

- Will this be beneficial for farmers?
  - for consumers/eater?
- Complex networks tie people into complex systems
- Will this benefit the soil?
- **My answer: Possibly, in part, if we make careful choices**

The Problem with ICT

- People inevitably think more ICT is better
- If ICT is seen as an end in itself we miss the point.
  - Use ‘Second Life’ to facilitate ‘First Life’
- **If ICT distances us from the soil, from living things, from nature, then we are failing!**
- This is a likely occurrence.
- What is missing are tools for discernment

Let the cucumbers speak

- Technology can hide and reveal
- but I want to ask the cucumber:
- Where do you come from?
- Who grew you?
- What is your story?

Thank you

http://www.smartagrifood.eu
http://thirlmere.aston.ac.uk/~kiffer/

Acknowledgements

- Much material in this presentation taken from SmartAgriFood proposal