# Context-Based Service Fusion for Personalized On-Board Information Support

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# Presentation Outline

- Introduction
- Context-Based Service Fusion
- Service Network Self-Configuration via Agent-Based Negotiation
- Case Study
- Conclusions and Future Work

# Introduction:
# CAIS laboratory projects & grants (2007-2014)

SPIIRAS

**Russian Academy of Sciences**

6 projects

**Ministry of Education & Science, Russia**

МИНИСТЕРСТВО ОБРАЗОВАНИЯ И НАУКИ
РОССИЙСКОЙ ФЕДЕРАЦИИ

4 projects

**Russian Basic Research Foundation**

**Russian Humanitarian Scientific Foundation**

РФФИ

26 grants

1 grant

FP6 IST – 1 project (IP “ILIPT”)

ENPI-Finland - 1 project

Bundesministerium
für Bildung
und Forschung

1 grant

NOKIA
Connecting People

5 projects

1 grant

FESTO

10 projects

STINT

**The Swedish Foundation for International Cooperation in Research and Higher Education**

2 grants

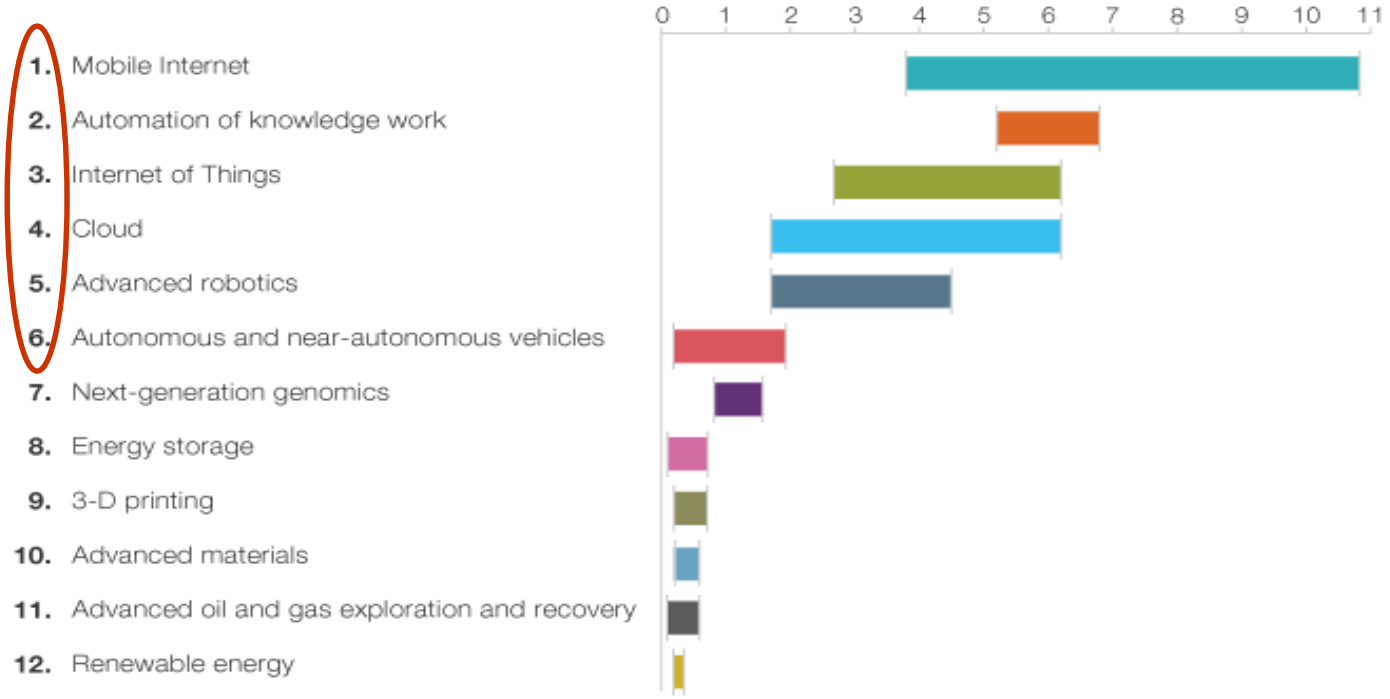
Si.
Svenska institutet

2 grants

# Introduction: top 12 technologies by McKinsey Global Institute (May 2013)

## A gallery of **disruptive technologies**

**Estimated potential economic impact of technologies across sized applications in 2025**, $ trillion, annual




SOURCE: McKinsey Global Institute

Notes on sizing: These economic impact estimates are not comprehensive and include potential direct impact of sized applications only. They do not represent GDP or market size (revenue), but rather economic potential, including consumer surplus. The relative sizes of technology categories shown do not constitute a "ranking," since our sizing is not comprehensive. We do not quantify the split or transfer of surplus among or across companies or consumers, since this would depend on emerging competitive dynamics and business models. Moreover, the estimates are not directly additive, since some applications and/or value drivers are overlapping across technologies. Finally, they are not fully risk- or probability-adjusted.

*Source:* Report MGI "Disruptive technologies: Advances that will transform life, business, and the global economy" (May 2013)
http://www.mckinsey.com/insights/business_technology/disruptive_technologies

# Introduction: motivation

- Modern navigation systems incorporate such ideas as
  - average traffic speed on roads,
  - generation of different routes (e.g., fastest, “green”, easiest, etc.)
  - indicate various points of interests (POI) along the route


- However, one cannot create a route from point A to point B e.g., “with a feature to see the most interesting POIs, crossing the country border where and when it the least crowded, and be in time for the ferry (all at the same time)”
- Besides, the system has to propose such routes based on the driver’s explicit and tacit preferences even though he/she has never been in this area before.

# Introduction: on-board infotainment system

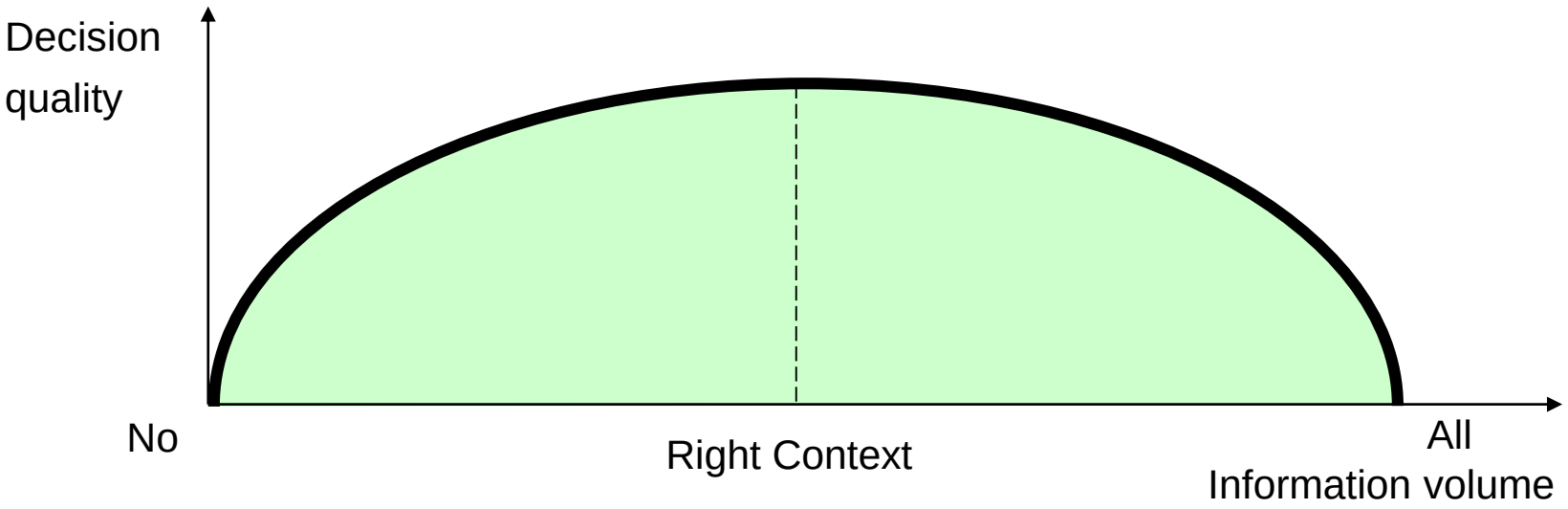

- Current developments of on-board information systems (i.e., Ford's AppLink, Chrysler's UConnect, Honda's HomeLink, etc.) make it possible to benefit from their integration with other information and decision support systems to provide a richer driving experience and seamless integration of information from various sources.

# Introduction: infomobility

- The proposed approach is a step to "infomobility" infrastructure, e.g. towards operation and service provision schemes whereby the use and distribution of dynamic and selected multi-modal information to the users, both pre-trip and, more importantly, on-trip, play a fundamental role in attaining higher traffic and transport efficiency as well as higher quality levels in travel experience by the users.

Ambrosino, G., Boero, M., Nelson, J. D. and Romanazzo, M., eds. (2012) "Infomobility systems and sustainable transport services", ENEA Italian National Agency for New Technologies, Energy and Sustainable Economic Development, pp. 336.

# Introduction: context




- Any information that can be used to characterize the situation of the considered entity where an entity is a person, place, or object that is considered relevant to the interaction between a user (driver) and a system (service network), including the user and system themselves
- Context represents only relevant information and knowledge from the large amount of those.

# Introduction: context-based service fusion

- The idea of service fusion originates from the concept of knowledge fusion, which implies a synergistic use of knowledge from different sources in order to obtain new information.
- Thus, service fusion in this work can be defined as synergistic use of different services to have new driver support possibilities not achievable via usage of the services separately.
- Context-based service fusion can provide a new, previously unavailable level of personalised on-board information support via finding compromise decisions taking into account proposals of various services and driver preferences.

# Introduction: possible benefits

- For each particular situation, there can be a large amount of feasible solutions for the drivers to choose from (i.e., the fastest route, the most spectacular route, a trip scheduled in accordance ferry schedule, etc.). The proposed technology could help to choose the most acceptable one for the driver in the current situation.
- Such a system could be capable to:
  - Propose most feasible trip route and schedule taking into account not only preferences of the driver but also taking into account decisions of the previously served drivers with similar interest
  - Take into account the context model of the current situation and its predicted development
  - Automatically apply for required services (such as ferry fees)
  - Continuously learn from all the users

# Introduction: example scenarios

- You want to re-fuel the car and have a dinner in a decent restaurant. Instead of finding a cheapest gas station, the system finds a gas station located near a restaurant, which has good feedback from its customers or belongs to the brand preferred by you.
- You are driving to a meeting. For some reason the meeting is postponed and you have some free time. The system will recommend visiting a POI, which is on your way.
- You are driving home after work. You need to buy some groceries and have a couple of shops to do this. The system recommends visiting a particular one of these, because your old friend Jack will be there at the same time.

# Context-Based Service Fusion: self-organising systems

- In the presented approach service fusion is based on the idea of self-organizing systems.
- Self-organizing systems are characterised by their capacity to spontaneously (without external control) produce a new organization in case of environmental changes.
- These systems are particularly robust, because they adapt to these changes, and are able to ensure their own survivability.
- Knowledge fusion from different sensors, services and components is decisive for efficient context-based self-organization.
- A self-organizing network is an interconnected network of multiple entities (self-interested agents) that exhibit adaptive action in response to changes in both the environment and the system of entities itself.

# Context-Based Service Fusion: collaboration principles

- The fusion of services can only be achieved if the following major principles of collaboration are used as the basis for self-organization:
  - *Contribution*: the services have to cooperate with each other to make the best contribution into the overall system's benefit – not into the agents' (services') own benefits.
  - *Task performance*: the main goal is to complete the task performance – not to get profit out of it.
  - *Non-mediated interaction*: the services operate in a decentralized community and in most of the negotiation processes there are no services managing the negotiation process and making a final decision.
  - *Common terms*: since the services work in the same system they use common terms for communication. This is achieved via usage of the common shared ontology.
  - *Trust*: since the services work in the same system they can completely trust each other (the services do not have to verify information received from other services).

# Context-Based Service Fusion: service fusion processes (1)

- The service fusion problem refers to integration of functionalities of different services to obtain new functionality, which is not possible when the services are used separately.
- The main feature of the service fusion lies in creation of synergetic effect from the integration of services.
- Based on the analysis of knowledge fusion studies, five service fusion processes can be distinguished.

# Context-Based Service Fusion: service fusion processes (2)

| # | Service fusion process | Service fusion result |
|---|---|---|
| **1** | Intelligent fusion of several heterogeneous services into a view that may be used by systems and humans as the basis for problem solving and decision making. Intelligent fusion assumes taking into account the semantic content of the services being fused | New complex problem that can be solved by the same service network |
| **2** | Inference of explicit knowledge from information / knowledge hidden in services fused | New knowledge about knowledge object |
| **3** | Combining different autonomous services in different ways in different scenarios, which results in discovery of new relations between different services | New relations between services |
| **4** | Re-configuration of the service network to achieve a new configuration with new capabilities or competencies | New capabilities / competencies of a service network |
| **5** | Involvement of knowledge from various services in problem solving that results in a new service | New complex service solving a problem |

# Context-Based Service Fusion: semantic interoperability

- Ontologies are widely used for problem domain description in modern information systems to support semantic interoperability.
  - Ontology is an explicit specification of a structure of a certain domain.
  - It includes a vocabulary for referring to notions of the subject area, and a set of logical statements expressing the constraints existing in the do-main and restricting the interpretation of the vocabulary.
  - Ontologies support integration of resources that were developed using different vocabularies and different perspectives of the data.
- An ontological model is used in the approach to solve the problem of service heterogeneity.
- This model makes it possible to enable interoperability between heterogeneous information services due to provision of their common semantics.

# Context-Based Service Fusion: self-contextualisation

- "Self-contextualization" is one of the key enablers for defining the current context of the "car-driver" system.
- It is the ability of the system to describe, use and adapt its behaviour to its context.
  - The context updates the parametric knowledge of services, which in turn defines their behaviour (capability to perform certain actions in order to change the own state and the state of the environment from the current to the preferred ones).
- The proposed approach exploits the idea of self-contextualization to autonomously adapt behaviours of multiple services to the context of the current situation in order to provide their services according to this context and to propose context-based decisions.
  - For this reason, the proposed conceptual model enables context-awareness and context-adaptability of the “planner service” and “driver and car context service”.

# Service Network Self-Configuration via Agent-Based Negotiation (1)

- Each service of the network has its own knowledge stored in its knowledge base.
  - This knowledge is described by a portion of the common shared ontology related to the current service's tasks and capabilities.
  - Capabilities, preferences and other information about the service are stored in its profile that is available for viewing by other services of the system.
    - This facilitates communication, which is performed via the communication module responsible for meeting protocols and standards that are used within the system.
- In order to make services capable not only to process requests for information, but also to intelligently anticipate, adapt, and automate their behaviour, they are assigned agent functionality (such service will be referred as "agent-based service").
  - Intelligent agent is an autonomous software entity that can navigate a heterogeneous computing environment and can, either alone or working with other agents, achieve some goals.

# Service Network Self-Configuration via Agent-Based Negotiation (2)

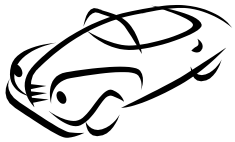
- The services communicate with other services for two main purposes:
  - establish links and exchange information & knowledge for better situation awareness;
  - negotiate and make agreements for coordination of their activities for a proposed solution.
- The services may also get information from various information sources (e.g. provided by Ford's AppLink).

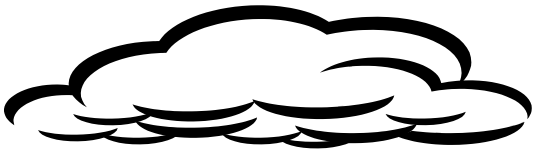
- "Utility" of the solution is proposed to be used as the objective function for negotiation taking into account driver preferences
  - characterizes the "usefulness" of the solution for the driver.
  - can be calculated as a weighted sum of utilities of various activities including in the solution.

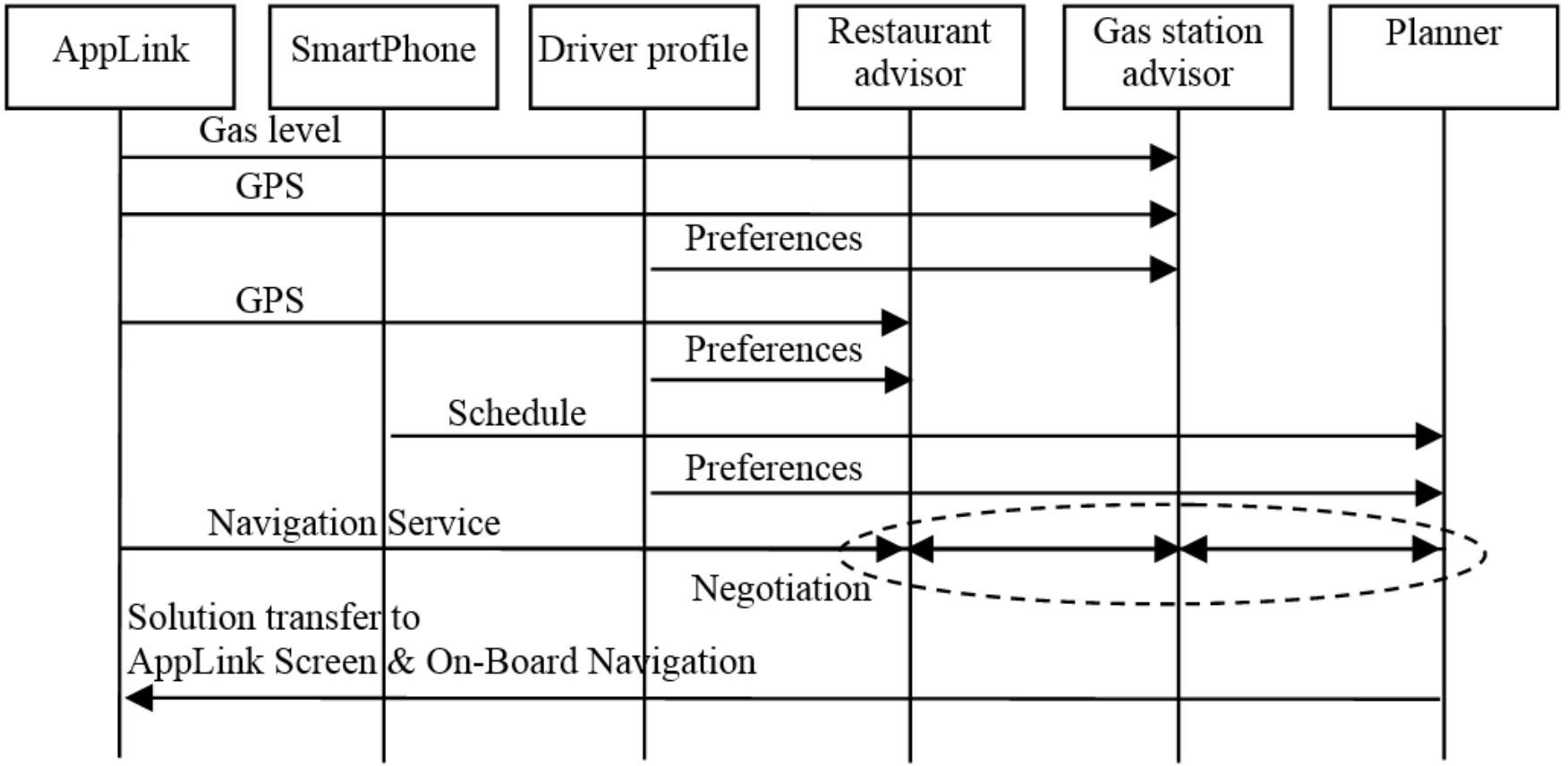
# Case Study: scenario

- You need to re-fuel the car (based on the automatic gas level identification) and have some rest and a dinner in a decent restaurant (based on the automatic fatigue level identification depending on how long you have been driving).
- Instead of finding a cheapest gas station, the system finds a gas station located near a restaurant, which has good feedback from its customers or belongs to the brand preferred by you.

# Case Study: service interaction







# Case Study: information sources

- In order for such a mechanism to operate efficiently, it requires a continuous adjustment of the services' utilities. This can be done through collecting information and knowledge from different sources.
  - User feedback (the driver can increase or reduce the utility of a certain service).
    - This is a reliable information source; however, in real life it is very unlikely, that the driver will provide such feedback.
  - Initial driver profile (the driver can fill out the initial preferences in his/her profile).
    - This is also a reliable information source but such information will be outdated after some time.
  - Analysis of driver decisions (the system can analyse if the driver followed the proposed solution, or which solution is preferred if several alternative solutions are presented to the driver).
    - This is a less reliable information source, but such information will never be outdated and development of learning algorithms can significantly improve such feedback.
  - Analysis of decisions of drivers with similar interests/habits.
    - This source originates from the method of collaborative filtering used in collaborative recommendation systems.

# Case Study: examples of obtained information

- Gas station advisor obtains current car location, gas level, and predefined driver preferences.
- Restaurant advisor obtains current car location and predefined driver preferences.
- Planner obtains driver's schedule from his/her smartphone and predefined driver preferences to estimate current time restrictions.

# Conclusions and Future Work

- The proposed context-based service fusion can provide a new, previously unavailable level of personalised on-board information support via finding a compromise decisions taking into account proposals of various services and driver preferences.
- The paper presents the concept, main supporting technologies and an illustrative case study for improved on-board information system.
- The main supporting technologies:
  - Ontology and context management
  - Profiling
  - Self-organization and self-contextualization
  - Agent-based negotiation
- Future work:
  - Selection of a technological framework for information & knowledge sharing (e.g. smart space)
  - Development of a negotiation model
  - Design of self-organization mechanisms and strategies

# Thank you!

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# Example of in-vehicle information support implemented in AppLink emulator