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Intelligent User Behaviour and Intelligent Systems: a Best Match

Moderator: Howard Williams, Heriot-Watt University, Edinburgh

Panellists:

- Mattias Wahde, Chalmers University of Technology, Sweden.
- Alexander Smirnov, SPIIRAS, Russia.
- Howard Williams.

Intelligent User Behaviour and Intelligent Systems: a Best Match

INTRODUCTION

- What is intelligence?
- Wikipedia – numerous definitions, no consensus
- Catell-Horn-Caroll theory
  - 10 broad abilities, 70 narrow abilities
- Includes knowledge, reasoning, understanding, learning,…

Intelligent User Behaviour and Intelligent Systems: a Best Match

INTRODUCTION

- Distinction between machine intelligence and human intelligence
- Computers designed as computational devices (not as artistic, emotional, …)
- Very good at computation but do it differently from humans
- Need to accept kind of intelligence we can get from computing devices

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Intelligent User Behaviour and Intelligent Systems: a Best Match

INTRODUCTION

- Current use of the term includes: intelligent devices, intelligent networks, intelligent systems.
- Smart – another word for intelligent (wikipedia)
- Smart appliances – cookers, TVs, …
- Smart vehicles – smart cars
- Smart buildings – smart homes, smart offices, …
- Smart areas – smart cities

Intelligent User Behaviour and Intelligent Systems: a Best Match

INTRODUCTION

- Many questions arise – e.g.
  - How far can one develop this intelligence?
  - What types of intelligence do we need/ not need?
  - What happens when conflicts arise between the system and the user?
  - What is the timescale for developments?
  - What should be the balance between different levels?

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Intelligent User Behaviour and Intelligent Systems: a Best Match

- First panelist: Prof. Mattias Wahde, Sweden.
- Prof of Applied Artificial Intelligence, Chalmers University of Technology, Gothenburg.
- Main research interests: autonomous robots, esp. partner robots and human-robot interaction.

Intelligent User Behaviour and Intelligent Systems: a Best Match

- Second panelist: Prof. Alexander Smirnov (PhD, DSc), Russia.
- Head of Computer Aided Integrated Systems Laboratory & Deputy Director for Research at SPIIRAS, Russian Academy of Sciences.
- PI on projects sponsored by Ford, Nokia, US DoD, EU and Russian, Swedish and German Research Foundations.

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Intelligent User Behaviour and Intelligent Systems: a Best Match

- Third panelist: Prof. Howard Williams, UK
- Heriot-Watt University, Edinburgh, Scotland.

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Intelligent User Behaviour and Intelligent Systems: a Best Match

- **Pervasive Computing** and **Pervasive Social Networks**

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- **Pervasive Computing** and **Pervasive Social Networks**
- Proliferation of sensors, devices, networks, services
- Need to provide intelligent support to user
- General (user-independent) vs Personal (user-specific) intelligence
- Intelligence in device vs intelligence with user

- **Pervasive Computing** and **Pervasive Social Networks**
- Intelligence with user - need to provide support to user to communicate and interact with devices in environment
- Context-aware, personalised, intelligent systems
- Pervasive Computing (or Ambient Intelligence)

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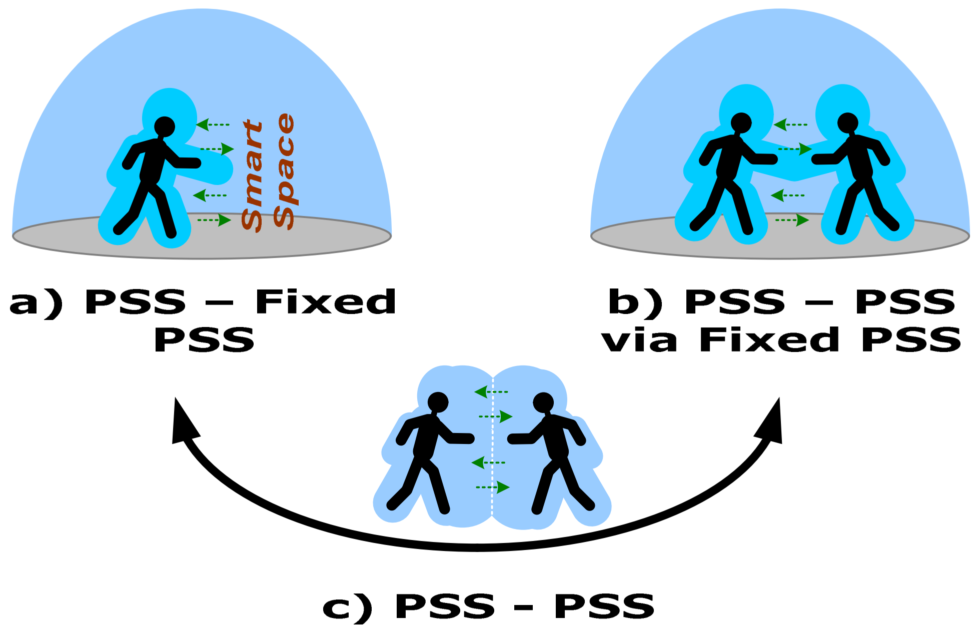
- **Pervasive Computing** and **Pervasive Social Networks**
- One form of pervasive computing system is fixed smart space
  - Smart Home, Smart Office
- Another form caters for mobile user
  - Ubiquitous systems
- Personal Smart Space – bridges the two

- **Pervasive Computing** and **Pervasive Social Networks**
- Each PSS keeps its own intelligence
- Communicates with other PSSs



Pervasive Computing and **Pervasive Social Networks**

EXAMPLE: SMART OFFICE

- Smart office PSS controlling lighting, temperature, data projector, ..
- User should keep user-specific intelligence including preferences, proactivity, intent.
- Office should keep general knowledge about sharing devices + “office” intelligence
- Environmental control – may need to arbitrate

- **Pervasive Computing** and **Pervasive Social Networks**

PERVASIVE SOCIAL NETWORKS

- Idea here is to combine pervasive systems with social networks
- Even more intelligence required
- Besides control over devices, need intelligence relating to privacy, trust, etc.

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- **Pervasive Computing** and **Pervasive Social Networks**

MAJOR CHALLENGES

- Representing “intelligence” – different kinds of knowledge and inference
- Learning – acquiring this intelligence through monitoring the user
- Striking a balance – user acceptability, conflicts

- **Pervasive Computing** and **Pervasive Social Networks**

SOCIETIES Project

- **Vision** is to develop a complete integrated solution which extends pervasive computing by merging with social computing to create a Pervasive Social Network system.
- To be evaluated in three real user trials: student, enterprise and disaster management.

Pervasive Computing and **Pervasive Social Networks**

- Both Pervasive computing systems and PSNs need intelligence
- Need both general intelligence and user-specific intelligence
- Need to acquire this both by user input and by machine learning
- Need it ASAP

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INTELLI 2012

Group Recommendation System for User-Centric Support in Virtual Logistic Hub:
Architecture and Major Components

Alexander Smirnov, Nikolay Shilov

Computer Aided Integrated Systems Laboratory (CAIS LAB)

St. Petersburg Institute for Informatics and Automation of the Russian Academy of Sciences (SPIIRAS)

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Presentation Outline

- Introduction
- Virtual logistic hub
- Approach
- Group recommendation system
- Knowledge representation
- User clustering
- Group recommendations
- Conclusion

SPIIRAS

Russian Academy of Sciences (RAS)

- Founded in 1724
- The research umbrella organization of the Russian Government
- 363 units (Research Institutes and Centers)
- 112,000 personnel: 55,100 Researchers (10,000 D.Sc., and 26,000 Ph.D.)

St.Petersburg Institute for Informatics and Automation (SPIIRAS)

- Founded in 1978
- Only 1 Russian Academy of Science Institute operating in Northwest Russia in Computer Science discipline
- 213 Personnel: 160 Researchers (38 D.Sc., and 57 Ph.D., 37 Ph.D. students)
- Grants Ph.D and Dr.Sc. (Technical) degrees

URL: http://www.spiiras.nw.ru

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CAIS Lab:
Financial Support (2005-2012)

NOKIA
Connecting People

- US Civilian Research & Development Foundation

STINT
- The Swedish Foundation for International Cooperation in Research and Higher Education

Russian Academy of Sciences

Svenska institutet

CAIS Laboratory: Current European Grants & Projects

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- Smart e-Tourism (*ENPI Cross Border Cooperation Programme, grant KA32, 2012-2014)*
- Multi-level Configuration of Complex Product (*FESTO, Germany, 2011-2012*)
- Collaborative Business and IT alignment in Medium-Sized Enterprises - COBIT (*Swedish Foundation for International Cooperation in Research and Higher Education, 2011-2014*)
- Context-Based Retrieval in Digital Libraries - CORELIB *(The Swedish Institute, 2007-2012)*
- Intelligent Information Logistics for SME-Networks *(International Bureau of the German Ministry for Education and Research, Germany, 2011-2012)*

CAIS Lab: Some Previous European Grants & Projects

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- Dynamic Logistics *(International Logistics Center of Deutsche Bahn and Russian Railway Company, Russia, 2011)*
- Smart Logistics *(Nokia Research Center, Finland, 2010)*
- Distributed Information Management in Smart Space *(Nokia Research Center, Finland, 2008-2009)*
- ILIPT - Intelligent Logistics for Innovative Product Technologies (*European Community – Research Program on Information Society Technologies, 2004-2008*).
  - ***Due to this project SPIIRAS was the first (and the only one) Russian organization involved into EU 6th FP projects related to the business area***
  - ***SPIIRAS was a leader of Knowledge Management Platform development for flexible supply network configuration***

Introduction:
SME business and personal travel

- Small and Medium business (SMEs) and personal travel
- via cars, buses and trains
- within the radius of 450-500 kilometers

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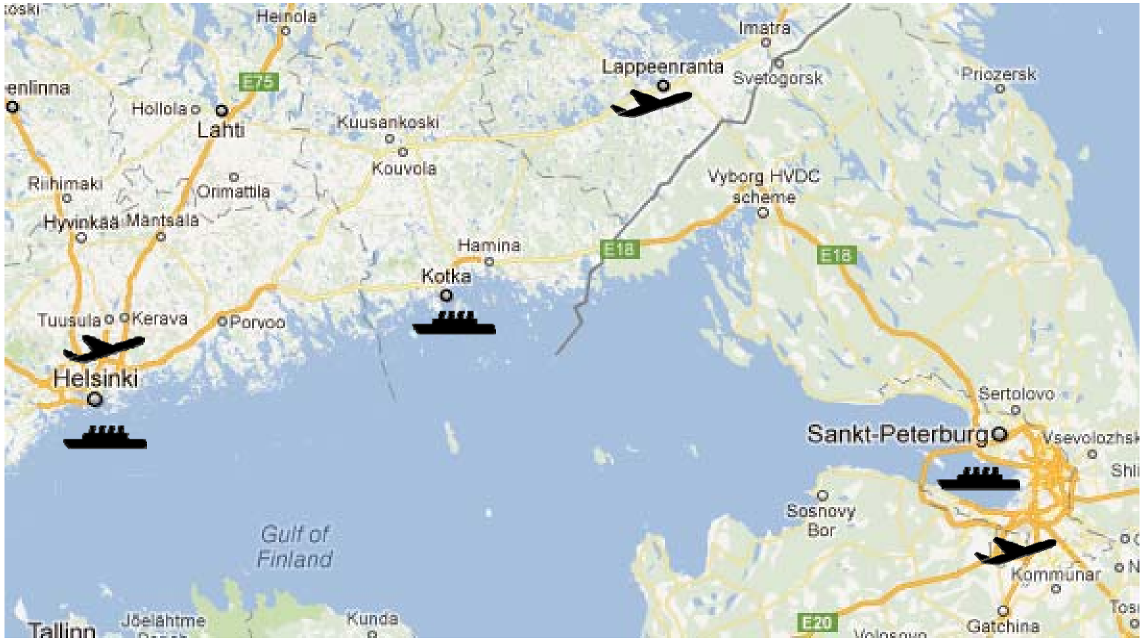
Introduction:
region as a transportation hub

- the region between of St. Petersburg, Russia and Helsinki, Finland together with nearby cities (Imatra, Lappeenranta, Kotka, Vyborg) could constitute a universal hub for travelling all around the world
- it has airports (Helsinki, Lappeenranta, and St. Petersburg), ferries (Helsinki, Kotka, and St. Petersburg), trains, buses, automobile road network.



Introduction: problem to be solved

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- today travelling problems
  - unpredictable situation at border crossing,
  - unknown traffic condition on the roads,
  - isolation of train, bus, and airplane schedules.
  - …
- the proposed approach is aimed at support of dynamic configuration of virtual multimodal logistics networks based on user requirements and preferences.
- the main idea is to develop models and methods that would enable ad-hoc configuration of resources for multimodal logistics.
  - based on dynamic optimization of the route and transportation means
  - take into account user preferences together with unexpected and unexpressed needs (on the basis of the profiling technology).

Introduction:
specific features

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- the small business and personal travelling is:
  - non-regular,
  - not expensive,
  - safe.
- the proposed approach assumes developing a group recommendation system for ad hoc generation of travel plans for the region (the South of Finland and St. Petersburg region) taking into account
  - the current situation on the roads and border crossings,
  - fuel management aspects,
  - travel time and distance.
- the increase of travelling will be a significant step towards development of the integrated economic zone in the Region.

Introduction: context-driven recommendation systems

- until recently, the most recommendation systems operated in the 2-dimentional space “user-product”
  - they did not take into account the context information, which, in most applications can be critical.
- a need in development of group recommendation systems based not only on previously made decisions but also on the contexts of situations in which the decisions were made.
- this gave a rise to development of context-driven collaborative algorithms of recommendation generation.

Introduction: other benefits

- the proposed general framework will be a channel for collecting user's feedback, preferences and demands for new services that users cannot find in the Region or quality of which shall be improved.
- not only the problem is identified, but in most cases immediate hints/suggestions can be provided regarding what shall be done to better serve users' needs.
- the framework will also significantly benefit to the ecological situation in the region via reducing not necessary transportation and waiting time for border crossing.
  - the carbon emission in the travelling sector can be significantly decreased via more efficient route planning, driving less, switching from car to rail, bus, cycle, etc. As a result, evolving of flexible energy and eco-efficient logistics systems can be considered as one of the significant steps towards the knowledge-based low carbon economy. (Global GHG Abatement Cost Curve v 2.0, 2009)

Virtual Logistics Hub: virtual collaboration

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- the idea of virtual logistic hub has already been mentioned in the literature (though it could have a different name, e.g., “e-Hub”), but it is still devoted very little attention in the research community.
- generally, virtual logistic hub represents a virtual collaboration space for two types of members:
  - transportation providers (who actually moves the passengers or cargo),
  - service providers (who provides additional services, e.g., sea port, border crossing authorities, etc.).
- these providers can potentially collaborate in order to increase the efficiency of the logistic network, however, it is not always the case.

Virtual Logistics Hub: a service for the end-users

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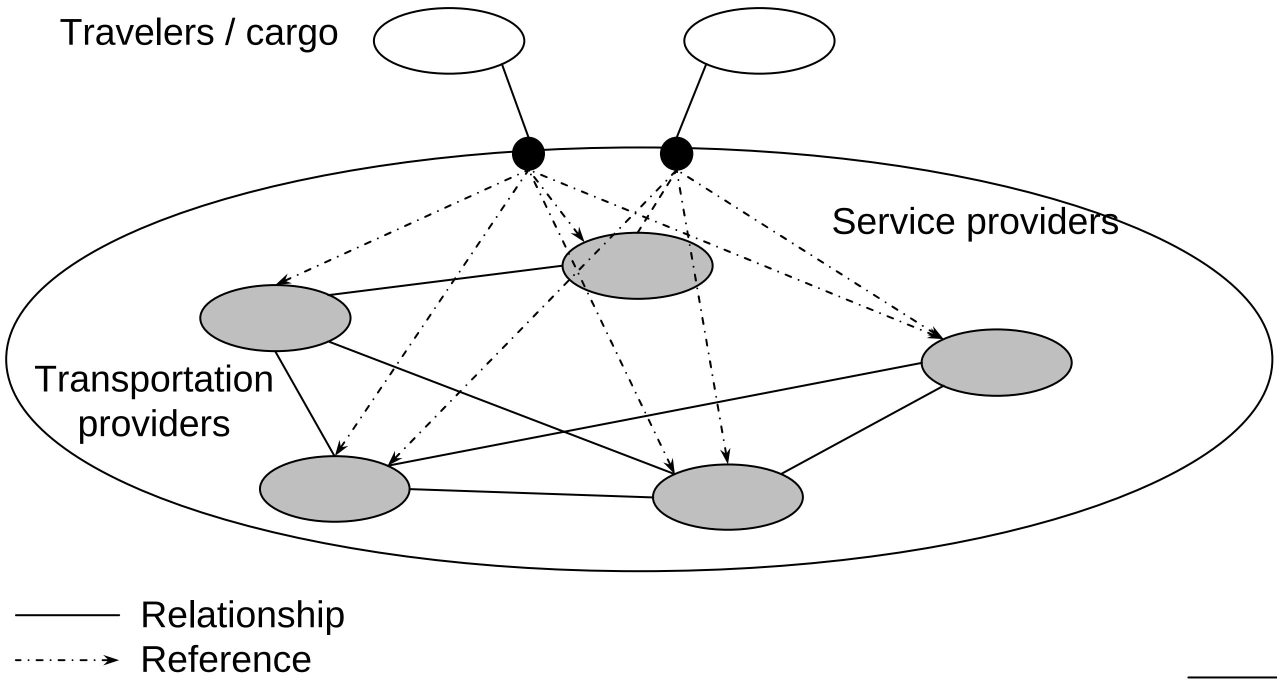
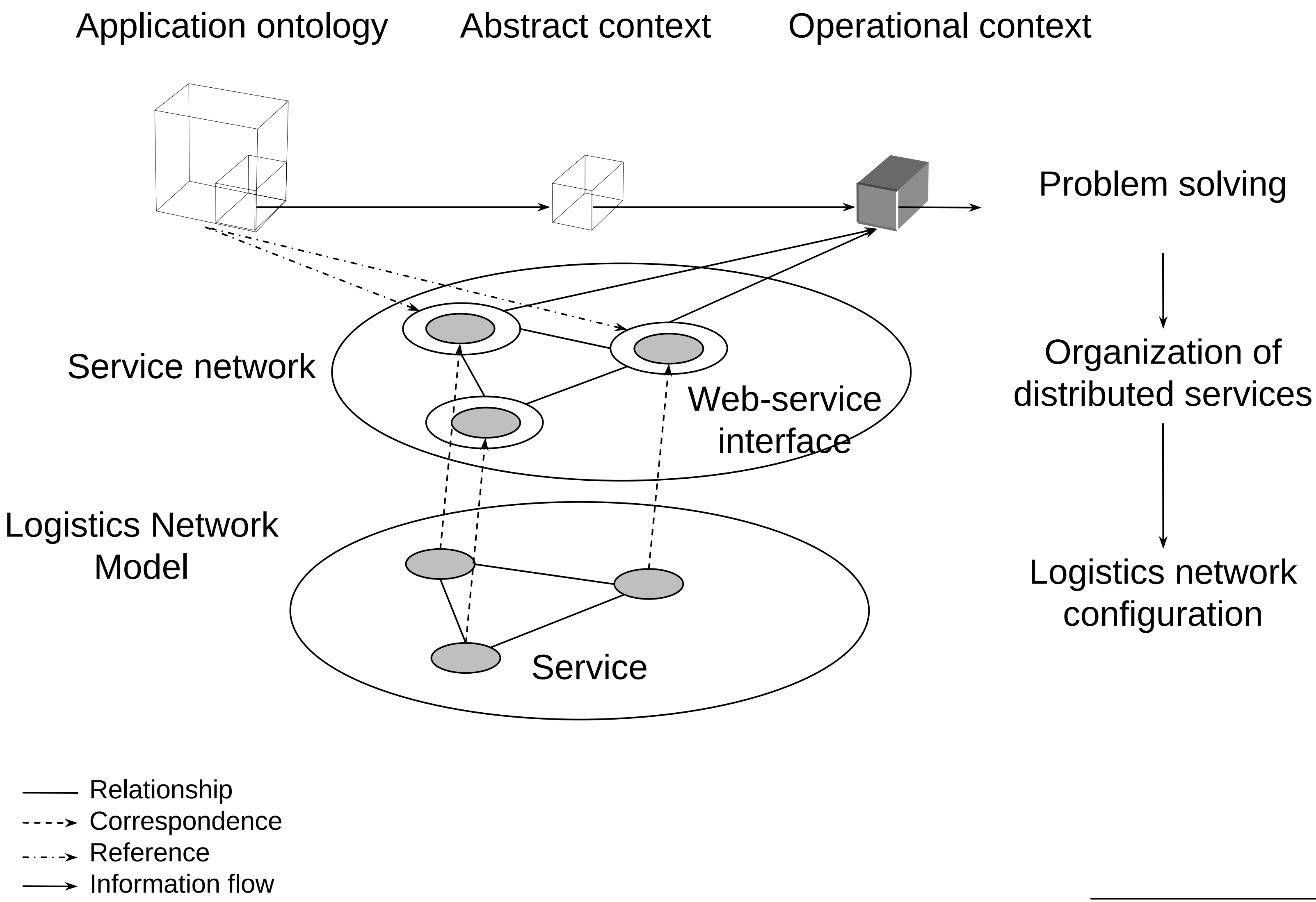
- The major idea of the virtual logistic hub is to arrange transportation based on the available schedules and capabilities of transportation and service providers, current and foreseen availability and occupancy of the transportation means and services.
- For the end-user (travelers or cargo owners), all this is hidden “under the hood”, and only the final transportation schedule is seen.



Approach: generic scheme



Approach: main principles

- represent logistic system members by sets of services provided by them
  - replace the configuration of logistic system with that of distributed services
- for the purpose of interoperability the services are represented by Web-services using the common notation and semantics described by the application ontology.
- the agreement between the resources and the ontology is expressed through alignment of the descriptions of the services modeling the resource functionalities and the ontology.
- the operation of the alignment is supported by a tool that identifies semantically similar words in the Web-service descriptions and the ontology.
- in the proposed approach the formalism of Object-Oriented Constraint Networks (OOCN) is used for knowledge representation in the ontology.

Approach:
context-driven configuration

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- depending on the problem considered the relevant part of Application Ontology (AO) is selected forming the abstract context that, in turn, is filled with values from the sources resulting in the operational context.
  - to reduce the amount of information to be processed.
  - to manage information relevant for the current situation.
  - the operational context represents the constraint satisfaction problem that is used during self-configuration of services for problem solving.

Group Recommendation System: compromise between group and individual interests

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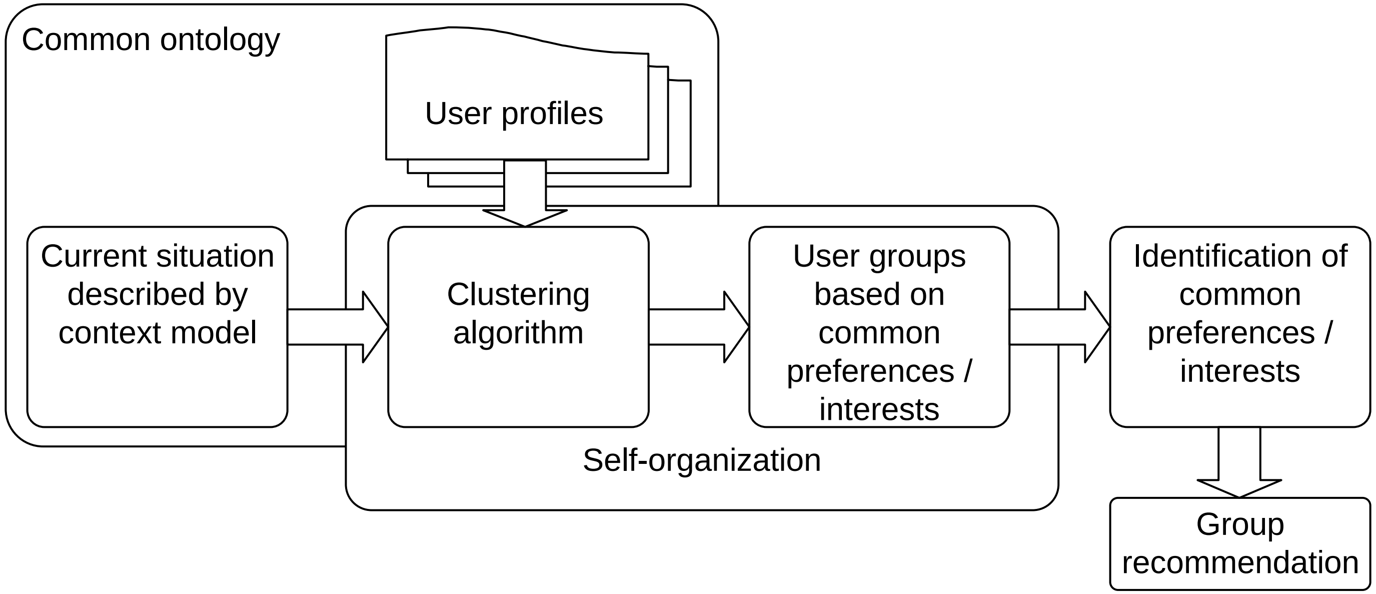
- generation of feasible transportation plans taking account explicit and tacit preferences requires strong IT-based support of decision making so that the preferences from multiple users could be taken into account satisfying both the individual and the group
  - group recommendation systems are aimed to solve this problem
- recommendation (recommending / recommender) systems have been widely used
  - in the Internet for suggesting products, activities, etc. for a single user considering his/her interests and tastes
  - in various business applications
  - in product development

Group Recommendation System: classification

- there are two major types of recommending systems:
  - content-based (recommendations are based on previous user choices)
  - collaborative filtering (recommendations are based on previous choices of users with similar interests)

- the second type is preferable for the domains with larger amounts of users and smaller activity histories of each user, which is the case for the logistics hub

Group Recommendation System: architecture



- the clustering algorithm is based on the information from user profiles
- the user profiles contain information about users including their preferences, interests and activity history
- the information is supplied in the context of the current situation (including current user task, time pressure and other parameters)
- the semantic interoperability between the profile and the context is supported by the common ontology
- usage of an appropriate knowledge representation formalism is one of the keys to development of an efficient clustering algorithm

Group Recommendation System: dynamic self-organisation

- the user profiles are dynamic and, hence, the updated information is supplied to the algorithm from time to time.
- as a result, the algorithm can run as updated information is received and update user groups.
- hence, the groups self-organize in accordance with the changes in the user profiles and context information.

Knowledge Representation: formalism

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- Object-Oriented Constraint Networks (OOCN).
- Application of constraint networks allows simplifying the formulation and interpretation of real-world problems which in the areas of management, engineering, manufacturing, etc. are usually presented as constraint satisfaction problems.
- OOCN support declarative representation, efficiency of dynamic constraint solving, as well as problem modelling capability, maintainability, reusability, and extensibility of the object-oriented technology.

Knowledge Representation: constraint satisfaction

- OOCN provides compatibility of ontology model for knowledge representation and internal solver representations.
- As a result, ontology-based problem model is described by a set of constraints and can be directly mapped into the constraint solver.
- A result of CSP solving is one or more satisfactory solutions for the problem modelled

Knowledge Representation: model compatibility

- Compatibility of CSP, ontology, and OOCN models is achieved through identification of correspondences between primitives of these models.

Ontology Model	OOCN	CSP
Class	Object	
Attribute	Variable	Set of variables
Attribute domain (range)	Domain	Domain
Axiom / relation	Constraint	Constraint

Knowledge Representation: OOCN

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- ontology (*A*) is defined as: $A = (O, Q, D, C)$ where
  - *O* – a set of *object classes* ("*classes*");
    - each of the entities in a class is considered as an *instance* of the class.
  - *Q* – a set of class attributes ("*attributes*").
  - *D* – a set of attribute domains ("*domains*").
  - *C* – a set of *constraints*.

Knowledge Representation: types of constraints (1)

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- $C^{I} = \{c^{I}\}$, $c^{I} = (o, q)$, $o \in O$, $q \in Q$ – accessory of attributes to classes;
  - the attribute *costs* (q_1) belongs to the class *ride* (o_1): $c^{I}_1 = (o_1, q_1)$;
- $C^{II} = \{c^{II}\}$, $c^{II} = (o, q, d)$, $o \in O$, $q \in Q$, $d \in D$ – accessory of domains to attributes;
  - the attribute *costs* (q_1) belonging to the class *ride* (o_1) is a real numebr: $c^{II}_1 = (o_1, q_1, \mathrm{R})$;
- $C^{III} = \{c^{III}\}$, $c^{III} = (\{o\}, True \vee False)$, $|\{o\}| \geq 2$, $o \in O$ – classes compatibility (compatibility structural constraints);
  - the class *cargo* (o_2) is compatible with the class *truck* (o_3): $c^{III}_1 = (\{o_2, o_3\}, True)$;

Knowledge Representation: types of constraints (2)

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- $C^{IV} = \{c^{IV}\}$, $c^{IV} = \langle o', o'', type \rangle$, $o' \in O$, $o'' \in O$, $o' \neq o''$ – hierarchical relationships (hierarchical structural constraints)
  - “is a” defining class taxonomy (*type*=0)
    - the *truck* (o_3) is a *resource* (o_5): $c^{IV}_1 = \langle o_3, o_4, 0 \rangle$;
  - “has part”/“part of” defining class hierarchy (*type*=1);
    - an instance of the class *ride* (o_1) can be a part of an instance of the class *travel* (o_4): $c^{IV}_2 = \langle o_1, o_4, 1 \rangle$;
- $C^V = \{c^V\}$, $c^V = (\{o\})$, $|\{o\}| \geq 2$, $o \in O$ – associative relationships (“one-level” structural constraints);
  - an instance of the class *cargo* (o_2) can be connected to an instance of the class *truck* (o_3): $c^V_1 = (o_2, o_3)$;

Knowledge Representation: types of constraints (3)

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- $C^{VI} = \{c^{VI}\}$, $c^{VI} = f(\{o\}, \{o, q\}) = True \vee False$, $|\{o\}| \geq 0$, $|\{q\}| \geq 0$, $o \in O$, $q \in Q$ – functional constraints referring to the names of classes and attributes.
  - the value of the attribute *cost* (q_1) of an instance of the class *travel* (o_4) depends on the values of the attribute *cost* (q_1) of instances of the class *ride* (o_1) connected to that instance of the class *travel* and on the number of such instances: $c^{VI}{}_1 = f(\{o_1\}, \{(o_4, q_1), (o_1, q_1)\})$.

User Clustering: algorithm

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- Due to the specifics of the tasks the implemented algorithm of user clustering is based on analysing user preferences and solutions selected by users and has the following steps:
  1. Preliminary linguistic analysis of preferences (tokenisation, spelling and stemming).
  2. Extract words/phrases from the preferences and solutions (text processing).
  3. Find ontology elements occurring in the extracted words and phrases.
  4. Construct weighted graph consisting of ontology classes and attributes, and users. Weights of arcs are calculated on the basis of (i) similarity metrics (i.e. they are different for different user solutions) and (ii) taxonomic relations in the ontology.
  5. Construct weighted graph consisting of users (when classes and attributes are removed, arcs' weights are recalculated).
  6. Cluster users graph.

User Clustering: finding ontology elements

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- Finding ontology elements (step 3) occurring in the extracted words and phrases is done in two ways:
  - via syntactic similarity
    - via the algorithm of fuzzy string comparison similar to the well-known Jaccard index
  - via semantic similarity
    - based on the machine-readable dictionary (e.g., Wiktionary)

User Clustering: syntactic similarity

- the algorithm calculates occurrence of substrings of one string in the other string
- Example: motor and mortar
  - string “motor” has 5 different substrings (m, o, t, r, mo) contained in the string “mortar”
  - The total number of different substrings in “motor” is 13 (m, o, t, r; mo, ot, to, or; mot, oto, tor; moto, otor)
  - The resulting similarity of the string “motor” to the string “mortar” is 5/13 or 38%.

User Clustering: semantic similarity (1)

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- The alignment operation is based on discovering words/phrases in preferences and solutions corresponding to names of the Application Ontology (AO) elements (classes, attributes, values).
- For discovering semantically close names a measure of semantic distance is used.

User Clustering: semantic similarity (2)

- why Wiktionary?
  - free
  - multilingual support
  - besides lexical relations keeps definitions of words

- the extracted machine-readable dictionary includes
  - a set of words defined in Wiktionary along with for each word
  - definitions given for this word
  - a set of synonyms, if any
  - a set of associated words
    - Words associated to a word are considered the hyperlinked words occurring in the Wiktionary definition given for this word.

User Clustering: semantic similarity (3)

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- the AO is a semantic network where names of classes, attributes and values specified in the AO constitute nodes of the network.
- the nodes corresponding to the AO concepts are linked to nodes representing their synonyms and associated words in the machine-readable dictionary.
- the links between the nodes are labelled by the weights of relations specified
  - ∞ for the same words
  - 0,5 for synonyms
  - 0,3 for associated words

User Clustering: semantic similarity (4)

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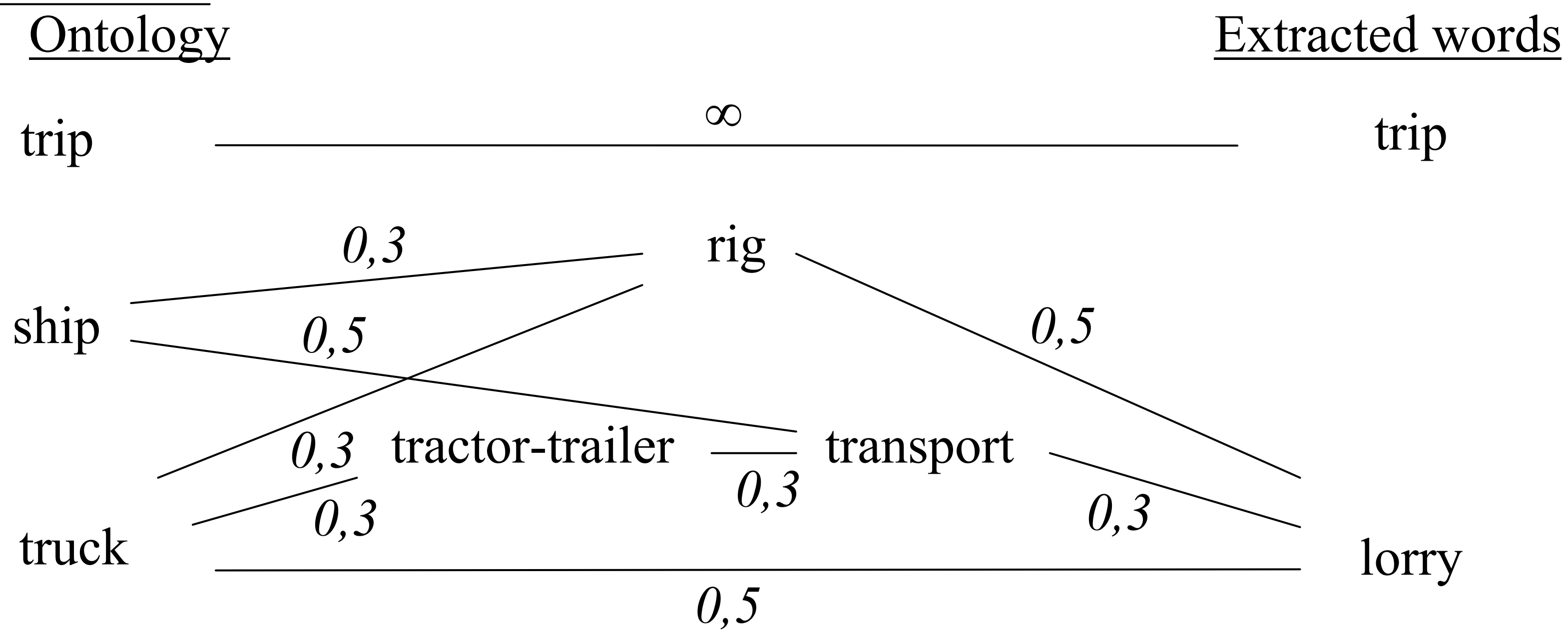
- the first step is parsing the preferences and solutions.
  - a set of meaningful words found.
- if this set contains words differing from the nodes of the semantic network built for the AO, the semantic network is extended with
  - the nodes representing the words extracted,
  - synonyms for these words from the machine-readable dictionary,
  - words associated in the machine-readable dictionary with the extracted words
  - appropriate links.

User Clustering: semantic similarity (5)

- Semantic Distance = 1 / (Sum of weights of possible paths)
- Weight of a path = Product of weights of its arcs

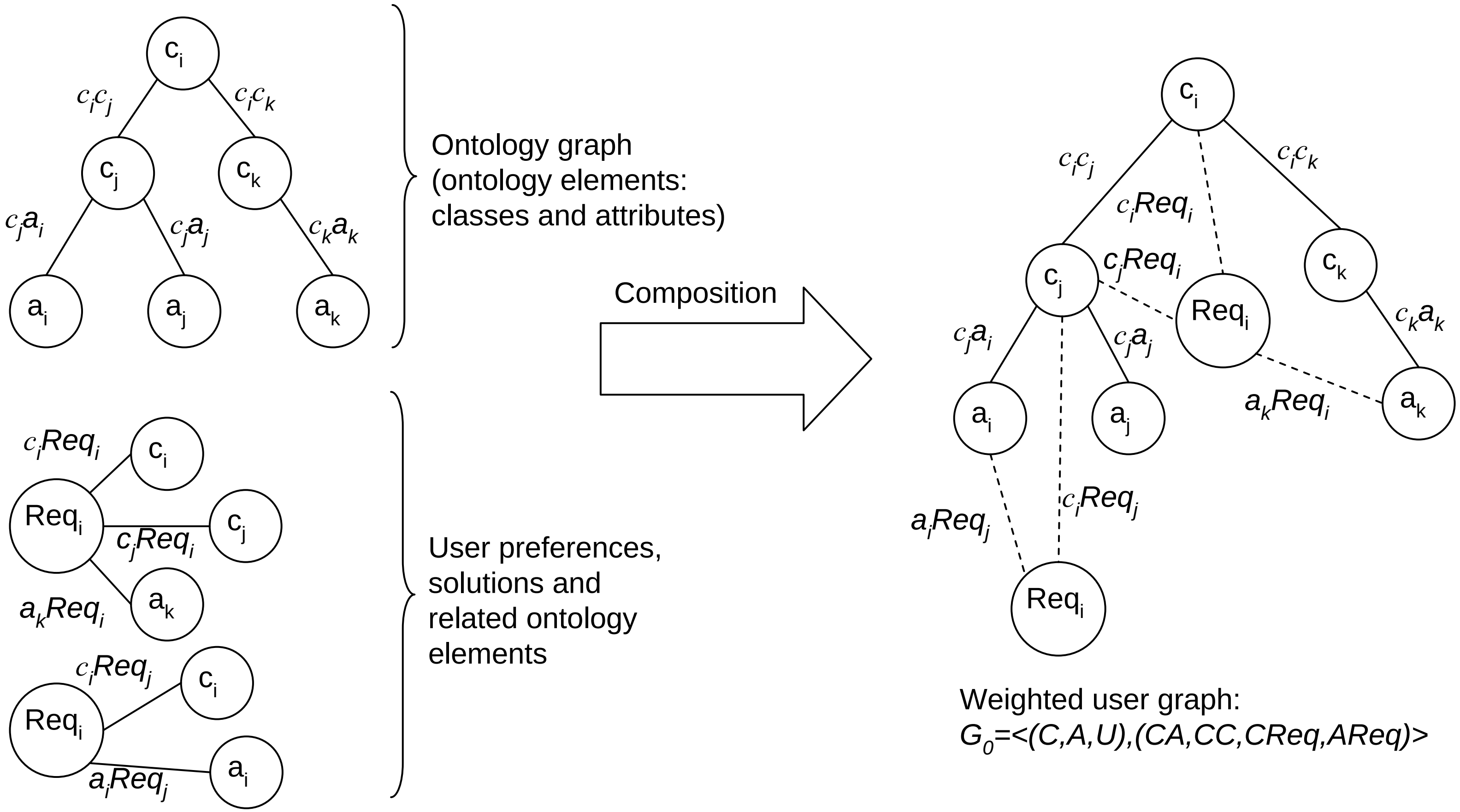
$$Dist(t_i, t_j) = \frac{1}{\sum_{S} \prod_{k=s_i}^{s_j} w_k}$$

User Clustering: semantic similarity (6)

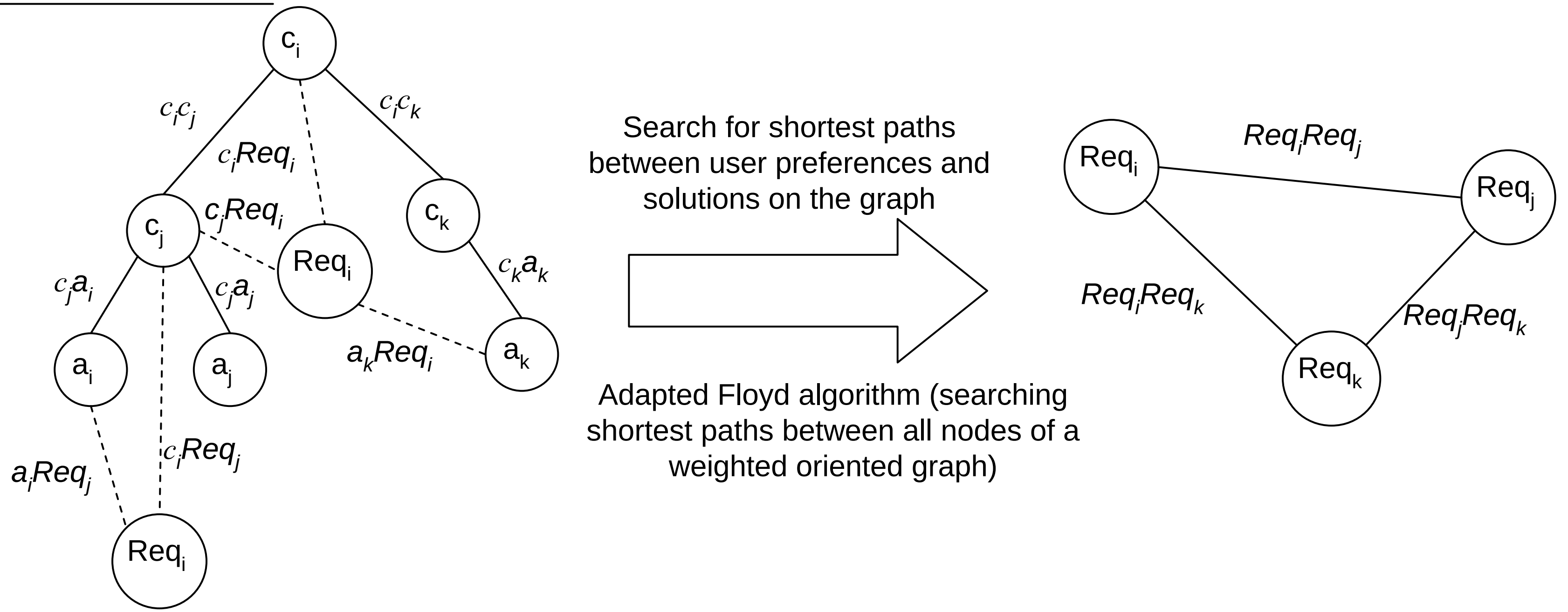


$$Dist(trip, trip) = 1 / \infty = 0$$
$$Dist(lorry, ship) = 1 / (0.5*0.3 + 0.3*0.5) = 3{,}33$$
$$Dist(lorry, truck) = 1 / (0.5*0.3 + 0.3*0.3*0.3 + 0{,}5) = 1.48$$

User Clustering: user graph construction



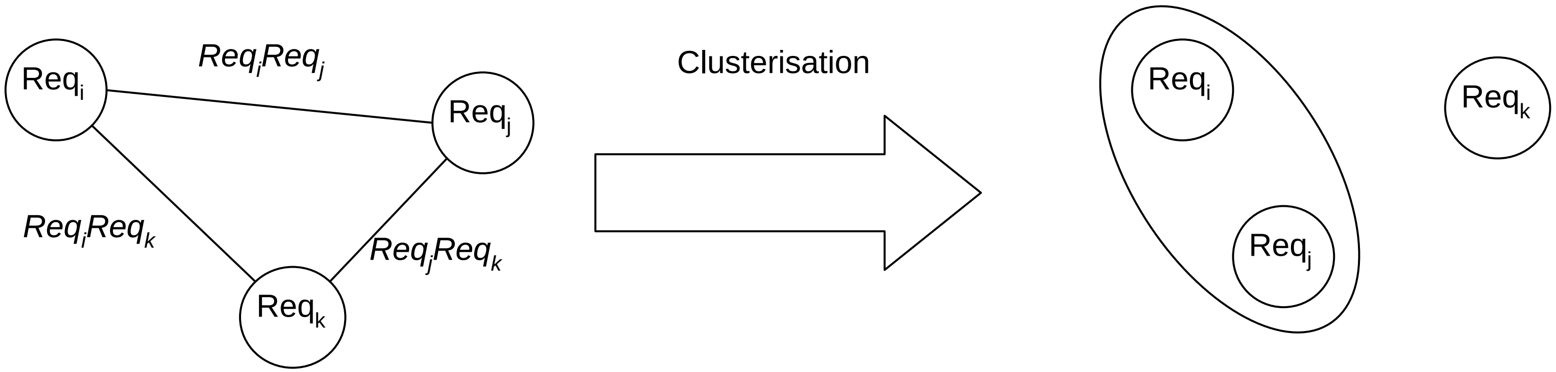
User Clustering: user graph clustering



Adapted Floyd algorithm:

```
for i from 1 to p do
 for j from 1 to p do
  for k from 1 to p do
   if i<>j and T[i,j]<> ∞ and i<>k and T[i,k]<> ∞ and
      (T[j,k]= ∞ or T[j,k]>T[j,i]+T[i,k]) then
         T[j,k] := T[j,i]+T[i,k]
   end if
  end for
 end for
end for
```

User Clustering: clustering result



User Clustering: algorithm advantages

- The developed ontology-based clustering algorithm has the following advantages compared to other clustering techniques
  - *domain-specific knowledge filter* using the ontology
  - *natural language processing*
  - *term extraction*, such as ontology classes and attributes, units of measures (e.g., “km” and “hrs”) can be extracted from the user preferences.

Group Recommendations: user preferences

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- User preferences consist of
  - attributes (properties) and/or their values,
  - classes (problem types),
  - relationships (problem structure)
  - optimization criteria that are usually preferred or avoided by the user.
- The preference revealing can be interpreted as identification of *patterns of the solution selection* (decision) by a user from a generated set of solutions by the system.
- The ability to automatically identify patterns of the solution selection allows to sort the set of solutions, so that the most relevant (to user needs) solutions would be in the top of the list of solutions presented to the user.

Group Recommendations: major tasks

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- Identification of *user preferences based on solutions generated for the same context*.
  - In this case the problem structure is always the same, however its parameters may differ.
- Identification of user *preferences based on solutions generated for different contexts*.
  - This task is more complex then the first one since structures of the problem are different.
- Identification of *user preferences in terms of optimization parameters*.
  - This task tries to identify if a user tends to select solutions with minimal or maximal values of certain parameters (e.g., time minimization) or their aggregation.
- Based on the clusters identified via the clustering algorithm described above the user preferences can be identified as common features of the solutions grouped into the clusters (recommendations).

Conclusion

- The paper presents an approach to development of group recommendation system for virtual logistic hub
- Virtual logistic hub performs ad-hoc transportation scheduling based on the available schedules, current and foreseen availability and occupancy of the transportation means and services even though they do not cooperate with each other
- The approach is based on application of such technologies as user and group profiling, context management, decision mining
- It enables for self-organization of user groups in accordance with changing user profiles and the current situation context.

- Presented research is at an early development stage
- The future work is aimed at implementation of the proposed system in a limited domain for validation of its applicability and efficiency.

SPIIRAS

Thank you!

Contact information: **Prof. Alexander Smirnov**

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Intelligent systems in elderly care

- The fraction of elderly people in the population increases rapidly in the developed world.
- For example, in the EU, the fraction of people aged 65 and over is expected to increase from around 17% (2010) to 30% in 2060.
- The fraction of people aged *80* and above is expected to increase from 5% (2010) to 12% (2060).

Intelligent systems in elderly care

- *Partner robots* and *smart homes* are examples of such intelligent systems.

- However, in order to be useful in elderly care, such robots must be able to
  - ... interact with their user(s) in a natural way,
  - ... understand and speak the user's language (i.e. not necessarily English or Japanese).
  - ...have a friendly (non-machine-like) demeanour.
  - ...show empathy.
  - etc.

Intelligent systems in elderly care

- Examples of problems and issues
  - Coping with (and preferably changing) generally negative attitudes in society towards robots and other AI systems.
  - Robots as a *help* for staff in elderly care, rather than *replacing* staff.
  - Making sure that the systems are adapted to the end users (i.e. elderly people) – these systems should be *desired* rather than *imposed*.
  - Considering aspects that are of particular importance in interaction with elderly people, for example coping with speech that may be difficult to recognize and interpret.

Intelligent User Behavior and Intelligent Systems: A Best Match

Context-Aware Operational Decision Support

Prof. Alexander V. Smirnov (smir@iias.spb.su)
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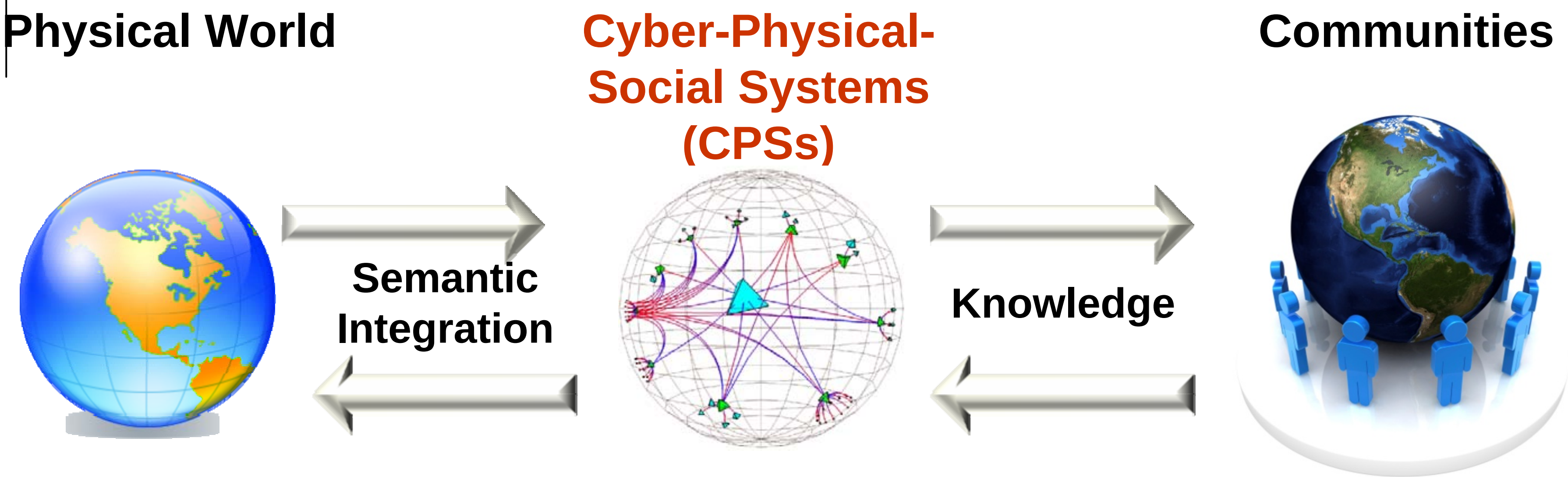
Introduction: Using Cyberspace to link Physical World Information to Communities



- CPS is a tight integration of physical systems and cyber (ICT) systems interacting in real time to decision support.
- CPSs rely on communication, computation & control Infrastructures, and social networks

Source: Adapted “Internet of Things: an early reality of the Future Internet. Workshop report. Prague, May 10, 2009”

Introduction:
Operational Decision Making Automation

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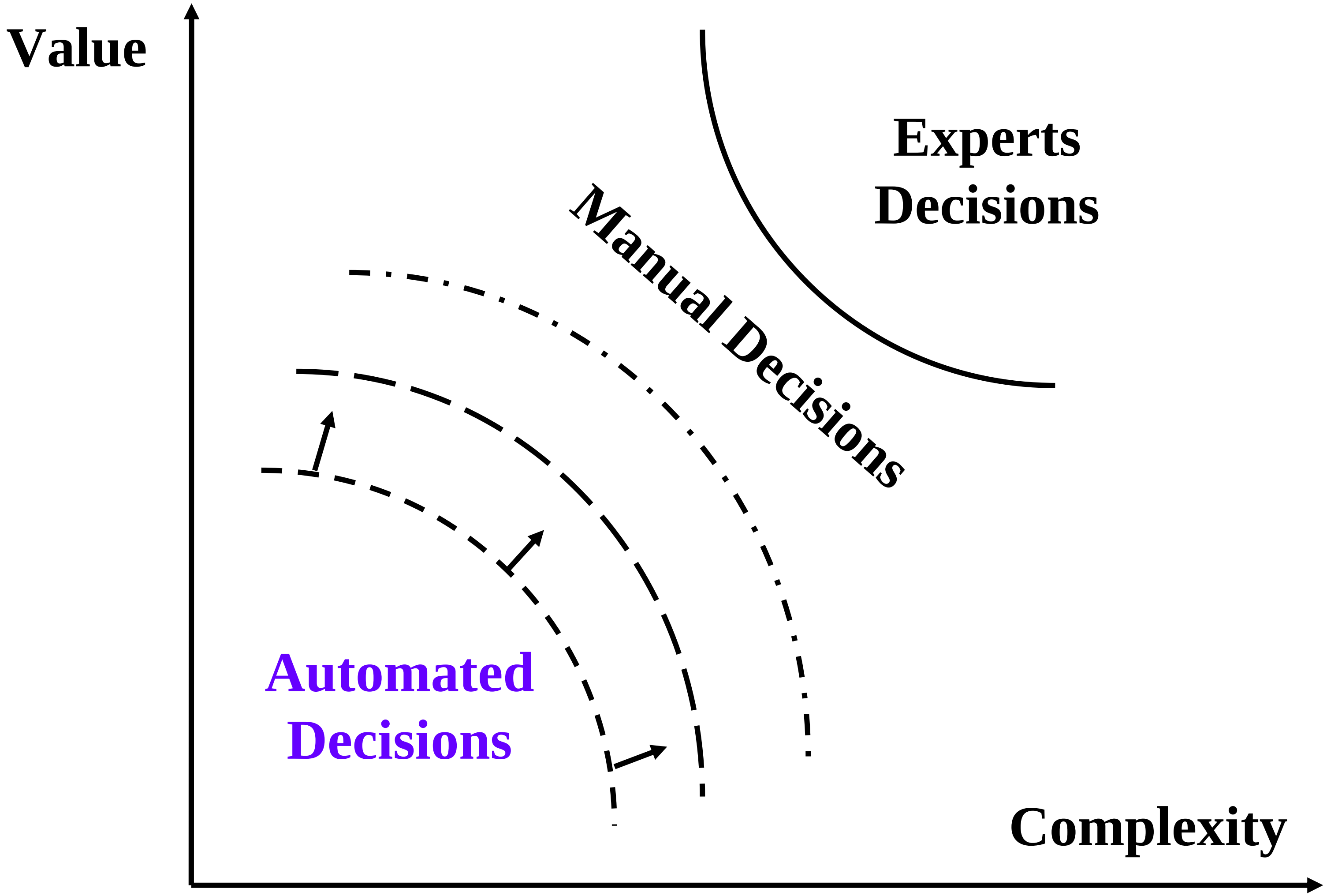

Source: Taylor J., and N. Raden,
Smart Enough Systems: How to Deliver Competitive Advantage by Automating Hidden Decisions. 2007

Introduction: Context Definition

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- *Context* is any information that can be used to characterize the *situation* of a component, where a component can be a *person, place, physical or computational object.*

- For problem solving *"context is what constraints a problem solving without intervening in it explicitly"* (Brézillon 1999).

- User Preferences (Profile) also are *contextual constrains* for problem solving.

Resource: Brézillon P., Context in problem solving: A survey, *The Knowledge Engineering Review*, vol. 14, no. 1, 1999.

Introduction: Context-Aware Operational Decision Support Motivation

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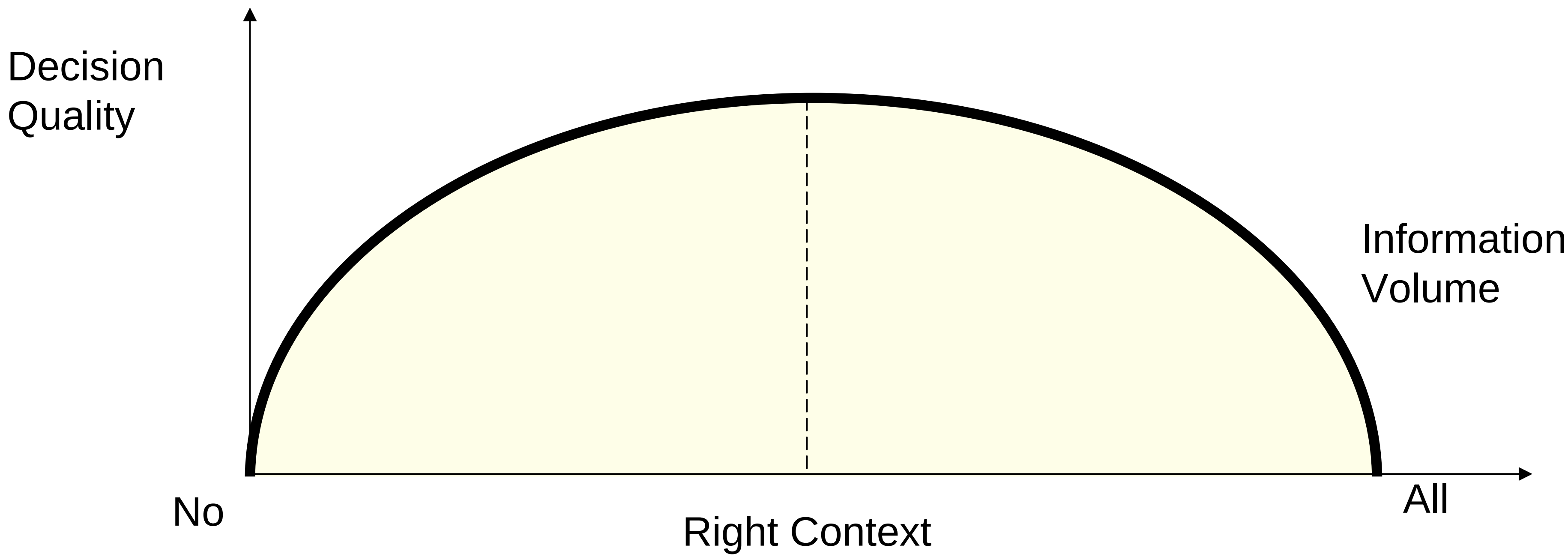

Theorem 1: 50% of the problems in the world result from *people using the same words with different meanings.*

Theorem 2: the other 50% of the problems results from *people using different words with the same meaning.*

Source: Kaplan S. The Words of Risk Analysis, *Risk Analysis*, Vol.17, N 4, August 1997

Introduction:
Operational Decision Making Issues

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- scenario-based information fusion related to
  a situation (a context);

- context-aware interoperability based on
  common ontology (knowledge model);

- on-the-fly decision support assistance based on
  Web-services and user profiles (created by using Decision Mining technology).

Context-Driven Methodology: Levels of Knowledge & Information Integration

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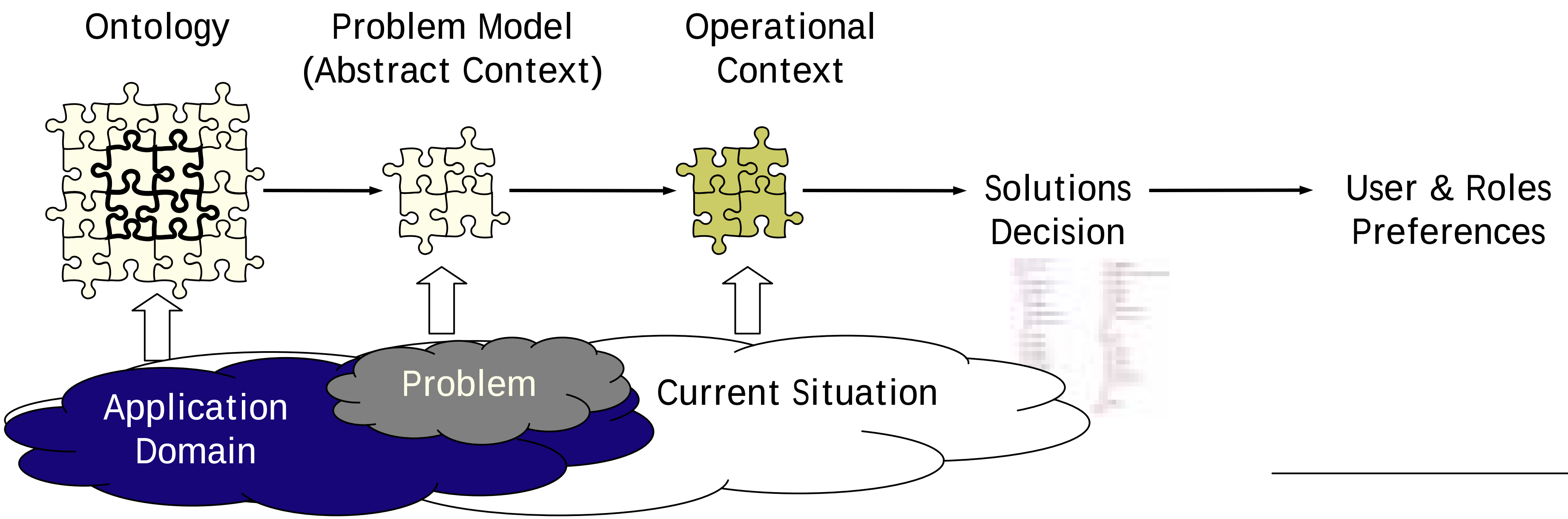
- **Domain level**
  - Integration of heterogeneous knowledge describing the domain knowledge
- **Task level**
  - Integration and formalization of tasks and problem-solving methods
- **Context level**
  - Integration of information and knowledge relevant to the problem or situation
- **Decision level**
  - Comparison of decisions & solutions by user roles



Service-Oriented Business Network: Multi-Level Reference Model and ICTs

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- Social networks: *Who knows whom? =>*
  Virtual Communities
- Knowledge networks: *Who knows what? =>*
  Human & Knowledge Management
- Information networks: *Who informs what? =>*
  Semantic-Driven Interoperability
- Work networks: *Who works where? =>*
  Services Network Self-Organization
- Competency networks: *What is where? =>*
  Competence Management & Profiles

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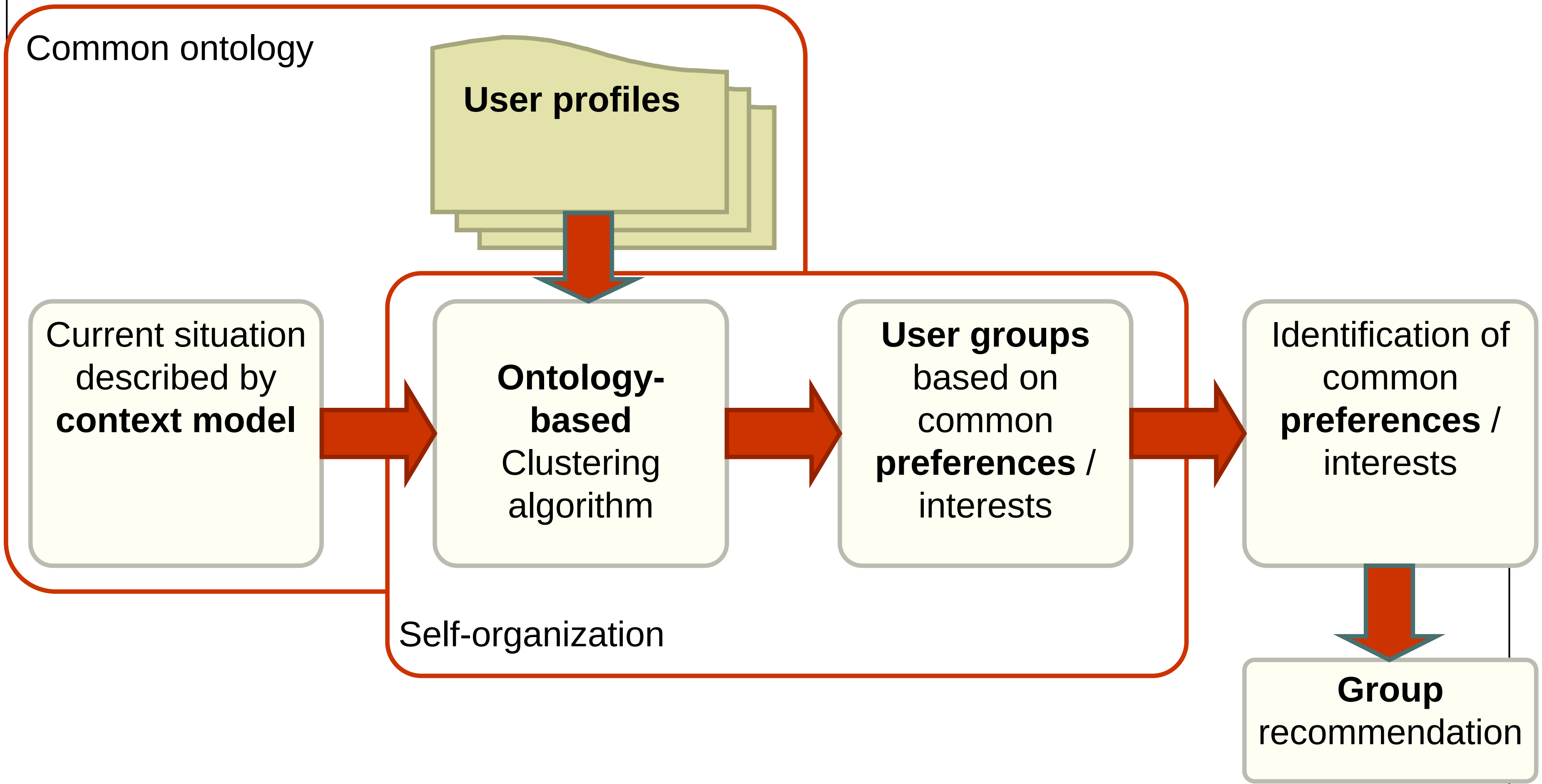
Context-Driven Recommendation Systems

- Recommendation systems are widely used
  - **in the Internet for suggesting products**, activities, etc. for a single user considering his /her interests and tastes,
  - in various applications.
- Group recommendation is complicated by the necessity to **take into account not only personal interests but to compromise between the group interests and interests of the individuals of this group**.
- The **most recommendation systems** operate in the 2-dimentional space **“user-product”.** They do not take into account **the context** information, which **can be critical.** As a result there is a **need in development of group recommendation systems based** not only on previously made decisions but also **on the context models** of situations in which the decisions were made.
- The **typical architecture** of the group recommending system is proposed based on three major components:
  - ***profile feature extraction from individual profiles,***
  - ***classification engine for user clustering based on their preferences,***
  - ***final recommendation based on the generated groups*.**

Group Recommendation System Architecture



Thank you!

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