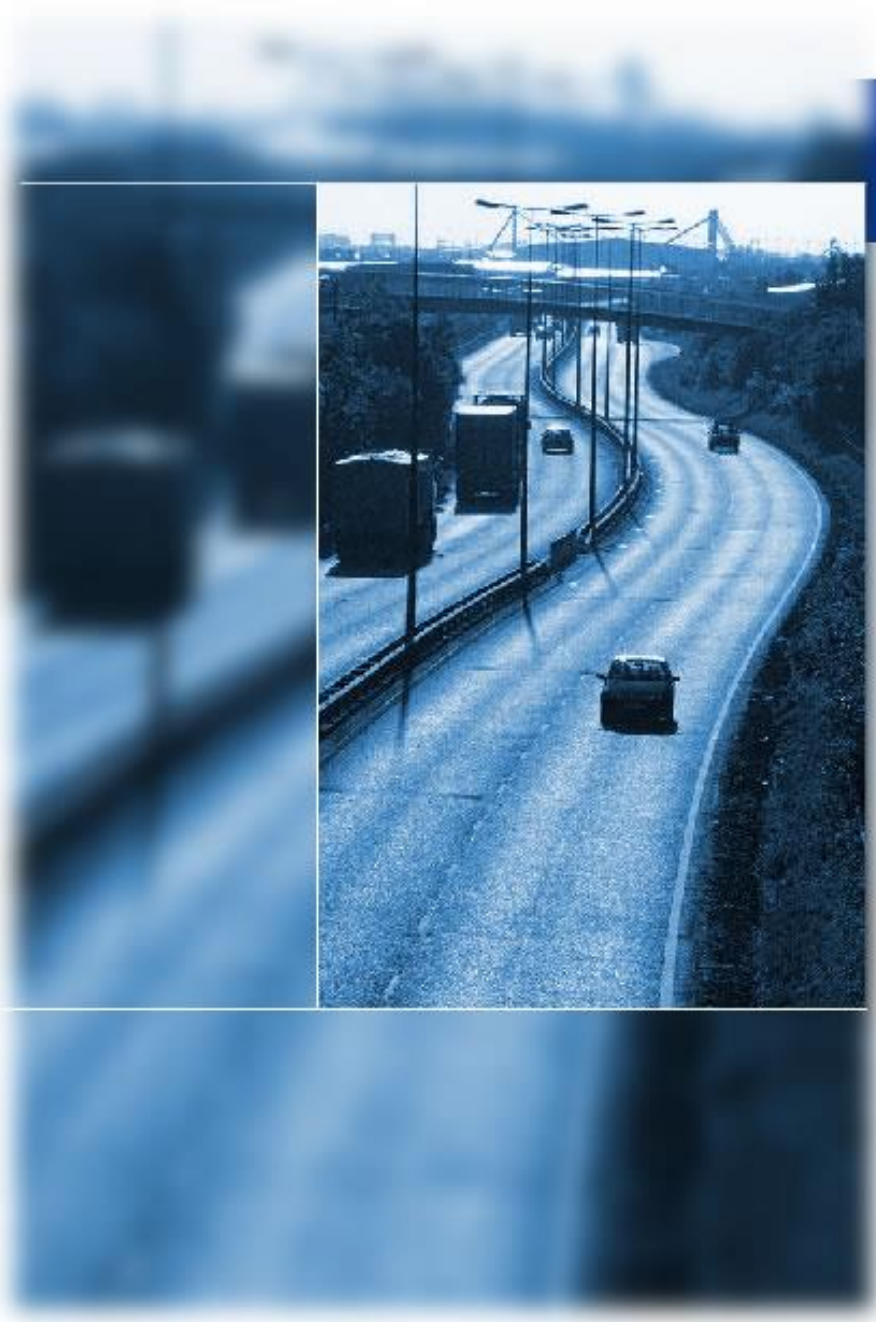


Czech Technical University in Prague

Faculty of Transportation Sciences

Department of Transport Telematics

SYSTEM ALLIANCES AS A TOOL FOR SOLVING SMART CITIES PROBLEMS

Fábera V., Novák M.,
Svítek M., Votruba Z.

Introduction

- The growth of inhabitants causes many problems in cities
  - *food, water, energy, medical care, transportation*
  - solving of these problems needs “sophisticated” approaches
- adoption of *Smart Cities* concept must be preceded by modeling at multiple levels

Smart Cities modeling – system alliances

- *Smart Cities* modeling:
  - suitable way = concept of system alliances
- System alliance
  - not widely known theory
  - the concept of systems alliances has been proposed by prof. Vlček in 2001

Smart Cities modeling – system alliances

- alliance should be identified as follows:
  - set of systems or automata or autonomous parts (modules, partial systems)
  - hybrid set of cooperating system
  - virtual system

System alliances background

- alliance of two or more parts /modules originates as:
  - product of random encounter
  - outcome of processes of contamination and immunity
  - construct

Characteristics of the alliance

- Features of alliance
  - need not be identified as a system
    - members do not need to have common goals, identity
  - members have to be autonomous
    - need not be identified as subsystems or automata
  - the place is emphasised on interfaces
    - communication, changes, control of alliance
  - **modelling processes on interfaces is crucial**

Characteristics of the alliance

- Modelling the interfaces in alliances:
  1. finite state machines
  2. grammars, languages and mutual translation
  3. quantum – like subsystems / wave information model

Interfaces in alliance

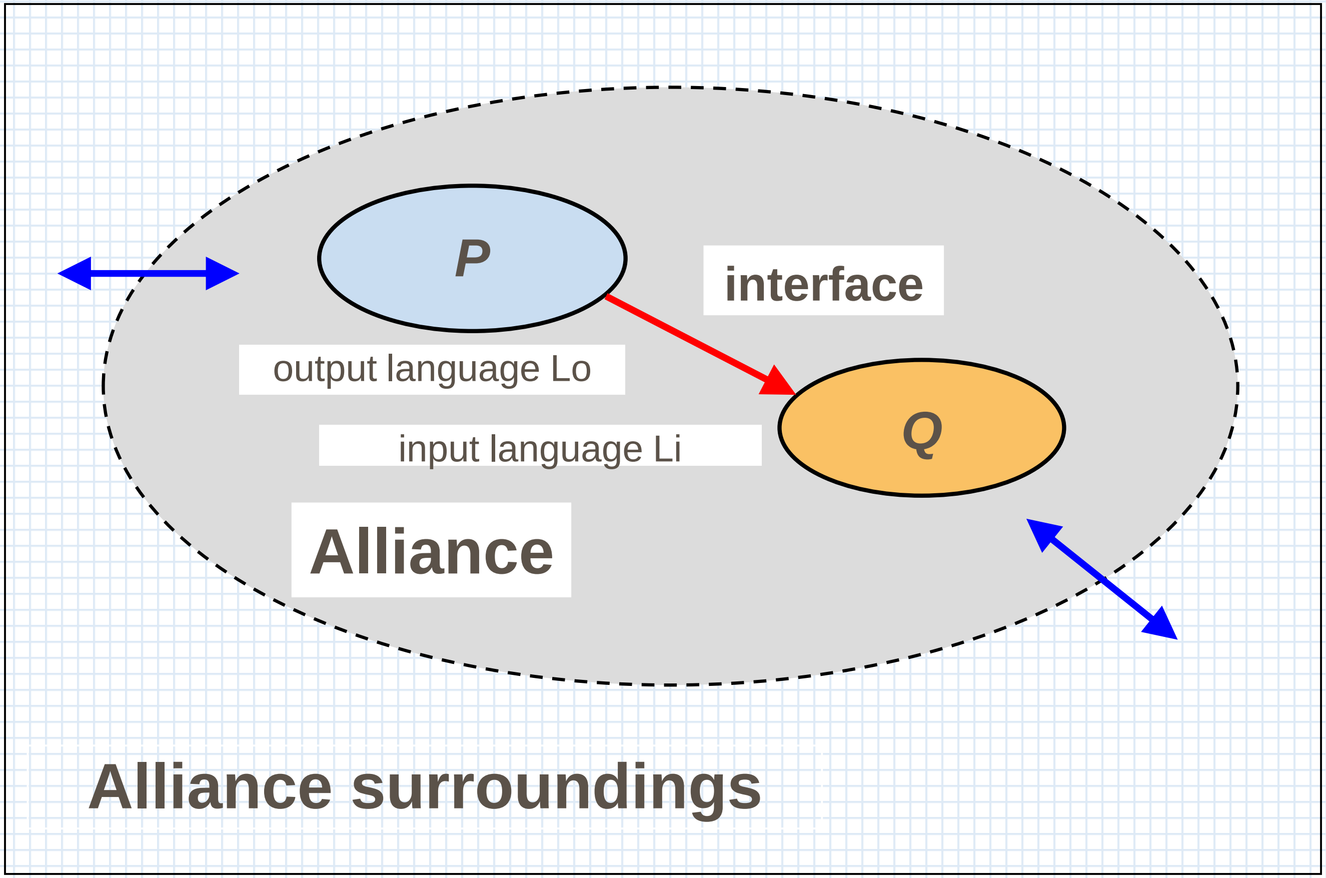
- Types of interfaces

machine	-	machine
machine	→	human
human	→	machine
human	-	human

Characteristics of the alliance

Multilingual approach, languages and their mutual translation

Multilingual approach



Multilingual approach

- two alliance members *P*,*Q* communicates through interface
  - *Q* is described by input language *Li*
  - *P* is described by output language Lo
- languages are generated (defined) by grammars

Multilingual approach

- Interfaces
  - machine – machine
    - regular languages
  - machine → human
    - regular, context free languages
  - human → machine
    - context languages
  - human – human
    - context languages

Language transformation on interface

- if Lo = Li or Lo $\subset$ Li,
  - the interface is regular and no transformations are needed
- if not
  - regularization process have to be started
    - transformation of one language (grammar) is necessary
      - the method is focused on regular languages, syntactic part of a language

Regular grammar

- *Regular grammar*

$$G = (N, T, P, S)$$

  - N – set of nonterminal symbols
  - T – set of terminal symbols
  - P – set of rules
  - S – start symbol $S \in N$

  - rule shape :
  - $A \to aB$ or $A \to a$, where $A, B \in N$, $a \in T$

Transformation task

- two regular grammars are given

$$G_1 = (N_1, T_1, P_1, S_1) \qquad G_2 = (N_2, T_2, P_2, S_2)$$

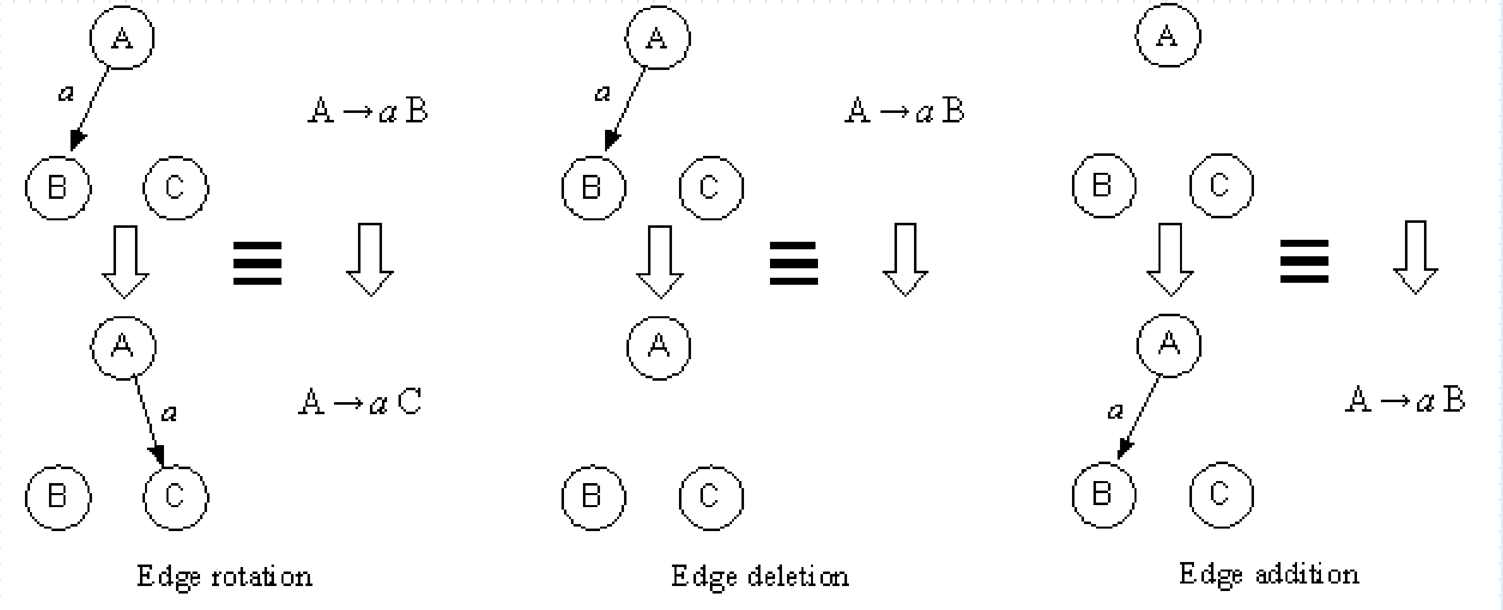
- assumptions:
  - $T_1 = T_2$ or $T_1 \subset T_2$ or $T_2 \subset T_1$
  - generally $N_1 \neq N_2$, $|N_1| = |N_2|$ or $|N_1| \neq |N_2|$
- problem:
  - change G_1 or G_2 so that both grammars are equivalent

Algorithm

1. If $T_1 \neq T_2$, insert missing terminal symbols into appropriate set
2. If $N_1 \neq N_2$, insert new nonterminal symbols into “smaller” set to be $|N_1| = |N_2|$
3. Find such optimal mapping of nonterminal symbols the count of transformation steps is minimal.
4. Apply transformation steps derived from optimal mapping.

Transformation steps

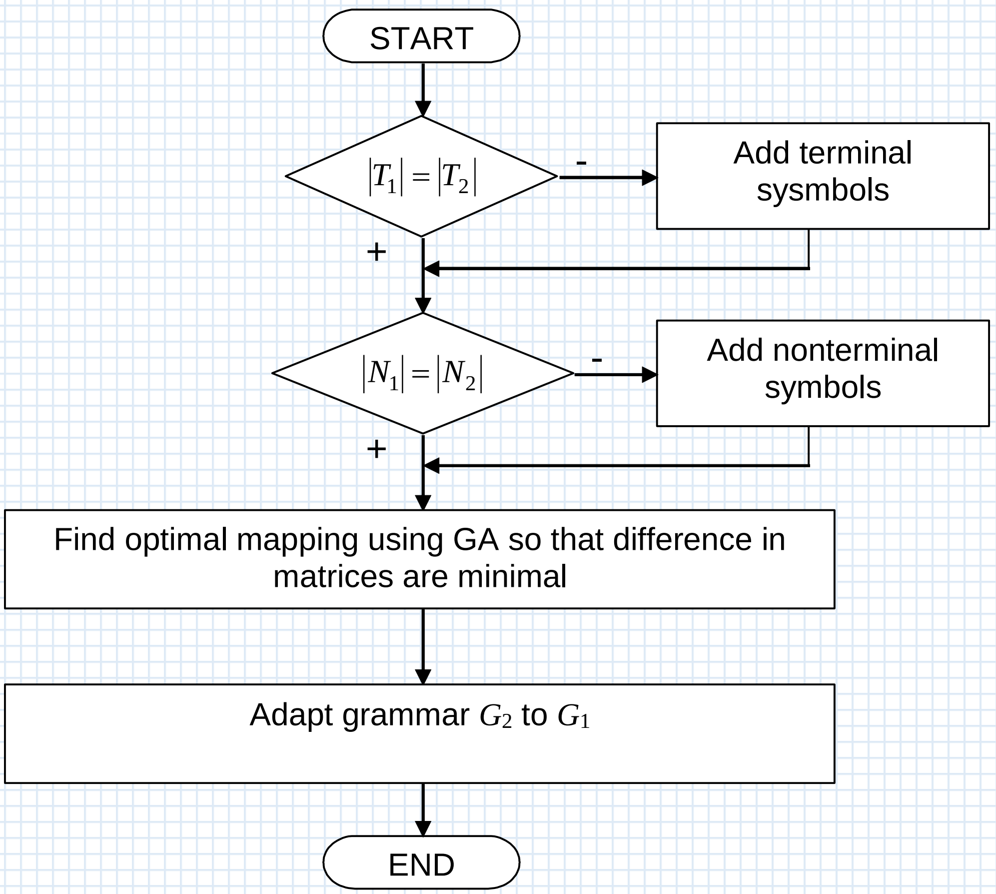
- three types of steps:
  - *changing right sight of the rule*
  - *deleting the rule*
  - *adding the rule*



Optimal mapping

- optimal mapping is searched using genetic algorithm
  - mapping must assigned start symbol of both grammars
  - regular grammar is represented like acceptor of language (FSM) - by matrix
  - fitness function computes the count of transformation steps; the computation is based on differences of mapped matrices

Algorithm


START
$|T_1| = |T_2|$
-
Add terminal sysmbols
+
$|N_1| = |N_2|$
-
Add nonterminal symbols
+
Find optimal mapping using GA so that difference in matrices are minimal
Adapt grammar G_2 to G_1
END

Example

$$G_I = \langle N_1, T_1, P_1, S \rangle$$

$$N_1 = \{S, R, J\}$$

$$T_1 = \{r, y, g\}$$

$$P_1 = \begin{Bmatrix} S \to rS, S \to yR, R \to yR, \\ R \to gJ, J \to gJ, R \to g \end{Bmatrix}$$

$$G_O = \langle N_2, T_2, P_2, A \rangle$$

$$N_2 = \{A, B, C, D\}$$

$$T_2 = \{r, y, g, t\}$$

$$P_2 = \begin{Bmatrix} A \to rA, A \to yB, B \to yB, B \to gC, \\ C \to gC, C \to g, A \to tD, D \to tD, D \to t \end{Bmatrix}$$

Transformation steps

1. Add non-terminal symbol NT to the set N_1
2. Add terminal symbol t to the set T_1
3. Found optimal mapping is: S to A, B to R, C to J, D to NT
4. Add three rules to the first grammar:

$$S \to tNT, NT \to tNT, NT \to t$$

Characteristics of the alliance

Wave Information Models of Alliance Interface

Wave information models

- A more sophisticated model of alliance interface can be based on the concept of Wave information models
- Superposition of states or even the entanglement concepts are suitable tools for recording non - orthogonal interface parameters and resulting phase sensitivity of the respective interface

Wave information models

- The information (syntax) flow $\Phi_i(t)$
  - describes dynamical property of data changes in bits per second [bit/s].
  - typically represents the system input / output data flows per time
- The information (semantic) content $I_i(t)$
  - characterizes the knowledge content measured in Joule per bit [J/bit]
  - for information systems (IT/ICT), the information content in [J/bit] can be alternatively defined as the number of “success events” caused by the receipt of one bit of information

Wave information models

- information power PI [J/s]

$$PI = \Phi_i(t) \cdot I_i(t)$$

- wave information model:
  - wave information flow

$$\psi_\phi(x) = \left|\psi_\phi(x)\right| \cdot e^{j \cdot \nu_\phi(t)}$$

  - wave information content

$$\psi_I(x) = \left|\psi_I(x)\right| \cdot e^{j \cdot \nu_I(x)}$$

Wave information models

- defined discrete quantities

$$\psi_\Phi = \alpha_{\Phi,1} \cdot \left|\Phi_1\right\rangle + \alpha_{\Phi,2} \cdot \left|\Phi_2\right\rangle + .. + \alpha_{\Phi,N} \cdot \left|\Phi_N\right\rangle$$

$$\psi_I = \alpha_{I,1} \cdot \left|I_1\right\rangle + \alpha_{I,2} \cdot \left|I_2\right\rangle + .. + \alpha_{I,N} \cdot \left|I_N\right\rangle$$

  - where $\Phi_1,..,\Phi_N$ and $I_1,...,I_N$ are possible values of information flow and information content of a set of studied alliances
  - complex parameters $\alpha_{\Phi,1},..,\alpha_{\Phi,N}$ represent wave probabilities characterizing alliances' interfaces that take into account flow/content synergies of each alliance's contribution together with their mutual dependences.

Wave information models

- information power PI [J/s]

$$\psi_{PI} = \psi_{\Phi} \otimes \psi_{I} = \alpha_{\Phi,1} \cdot \alpha_{I,1} \cdot \left|\Phi_1, I_1\right\rangle + \ldots + \alpha_{\Phi,1} \cdot \alpha_{I,N} \cdot \left|\Phi_1, I_N\right\rangle + ..$$

$$\ldots + \alpha_{\Phi,N} \cdot \alpha_{I,1} \cdot \left|\Phi_N, I_1\right\rangle + \ldots + \alpha_{\Phi,N} \cdot \alpha_{I,N} \cdot \left|\Phi_N, I_N\right\rangle$$

  - where each i,j-th components of alliances $\left|\Phi_i, I_j\right\rangle$ represent particular value of information power that characterizes the processing of the information flow and information content

Wave information model

- information power computed for all alliances' components in renormalized form can be expressed as:

$$\psi_{PI} = \beta_1 \cdot \left| K_1 \right\rangle + \beta_2 \cdot \left| K_2 \right\rangle + .. + \beta_r \cdot \left| K_r \right\rangle + ..$$

  - this approach yields to the resonance principle between the alliances' information flow and information content through interfaces represented through phase parameters. It enables modeling deep perception and new soft systems categories both for input/output parameters of each alliance's interface

Závěr

Thank you for your attention