RelEx
Visualization for Actively Changing Overlay Network Specifications

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Focus

Nested Model

domain problem characterization

data/task abstraction

visual encoding/interaction

algorithm

Munzner, InfoVis 2009
Focus

Nested Model

domain problem characterization

data/task abstraction

visual encoding/interaction

algorithm

Munzner, InfoVis 2009
What are network analysts doing?
**Network Vis**

Data and Tasks?

What are network analysts doing?

**Social Network Analysis!**

SOCIAL NETWORKS

Abstract Tasks

1. Find clusters
SOCIAL NETWORKS

Abstract Tasks

1. Find clusters
2. Find high-degree nodes
Social Networks

Abstract Tasks

1. Find clusters
2. Find high-degree nodes
3. Find bridge nodes
SOCIAL NETWORKS

Abstract Tasks

1. Find clusters
2. Find high-degree nodes
3. Find bridge nodes
4. Understand temporal dynamics
SOCIAL NETWORKS

Abstract Data

Single (directed) graph
SOCIAL NETWORKS

Abstract Data

Single (directed) graph

Node scalability challenge
Network Vis beyond Social Networks

email, academic papers?
Design Study: **In-car network engineering**
Radically different task and data abstractions

Understanding diversity is crucial to ensure applicable research\textsuperscript{1,2}

\textsuperscript{1} Borgatti (2005): Centrality and network flow.
Problem characterization and abstraction: Data
DATA

In-car Electronics
DATA ABSTRACTION

Base: Physical Network

~100 ECU (nodes)
DATA ABSTRACTION

Base: Physical Network

~100 ECU (nodes)
10-15 Bus systems (edges)
DATA ABSTRACTION

Overlay: Logical Network

~100 ECU (nodes)

ECU

ECU

ECU

ECU

signal a

e.g. “speed”
DATA ABSTRACTION

Overlay: Logical Network

~100 ECU (nodes)

~10k signals (edges)
DATA ABSTRACTION

Mapping: Signal Path Network
Data Abstraction

Mapping: Signal Path Network
DATA ABSTRACTION

Mapping: Signal Path Network
DATA ABSTRACTION

Mapping: Signal Path Network

~30k signal paths (edges)
DATA ABSTRACTION

Differences

- Overlay network
- Path scalability
  (few nodes / dense edges)

- Simple (directed) graph
- Node scalability
Problem characterization and abstraction: Task
Task Abstraction

Mapping

logical

physical

signal path

Specify
Traffic Optimization

Many constraints

bandwidth ... delay/real time ... path length ... load balance ... reliability ... money ...

-- engineer, BMW --
**Task Abstraction**

External Change Requests

(logical) = (physical) (= signal path)

Change

(trivial requests might lead to complex changes)
TASK ABSTRACTION

Differences

Implement **active** changes

Understand **passive** changes
Low-level
Tasks
LOW LEVEL TASKS

Queries about relations

Which ECU is communicating with which ECU?
Which signals do they exchange?
What is the path the signals take? ...
LOW LEVEL TASKS

Query complexity

- complex queries
- simple queries

- physical
- logical
- signal path

Query complexity

33
LOW LEVEL TASKS

Query complexity

simple queries

2-way relations

complex queries
LOW LEVEL TASKS

Query complexity

complex queries

overview

simple queries
LOW LEVEL TASKS

Query complexity

complex queries

simple queries

Unsupported need: **Logical Overview**

Unsupported need: **All path of a Signal**

physical

logical

signal path

query complexity

L
LOW
LEVEL
TASKS

supported:

simple queries

complex queries
**RELEX:**

Relation Explorer
RELEX: Logical Overview

**Logical Network**

- multigraph
- 100 nodes / 10k edges
**RELEX: Logical Overview**

**Logical Network**
- Multigraph
- 100 nodes / 10k edges

**Signal Count Network**
- Directed graph
- 1k weighted edges
**Logical Overview**

**Logical Network**
- Multigraph
- 100 nodes / 10k edges

**Signal Count Network**
- Directed graph
- 1k weighted edges

**Visual Encoding:**

**Size-Coded Matrix**

- Multigraph: 100 nodes / 10k edges
- Directed graph: 1k weighted edges

**Vis Guideline [Ghoniem 2005]**

**Matrix for dense graphs**
RELEX:
Logical Overview
**RELEX:**

All Path of a Signal

**Vis Guideline [Ghoniem 2005]**

Node-link for path following tasks

**SIGNAL PATH NETWORK**

filtered by signal
MORE STUFF: Support of Current Practices
MORE STUFF:
Cross-Network Relations

Linking & Brushing
Mid-level Interests
INTERESTS

Bus communication patterns
INTERESTS

Bus communication patterns

Within-bus

Between-bus
<table>
<thead>
<tr>
<th>Introvert</th>
<th>Extrovert</th>
</tr>
</thead>
<tbody>
<tr>
<td>通信模式</td>
<td>通信模式</td>
</tr>
</tbody>
</table>

**INTRESTS**

**Bus**

**communication patterns**

introvert vs. extrovert
INTERESTS

Bus communication patterns

introvert vs. extrovert
Methods

How we did it?
1. Problem characterization & abstraction

3 month

- Embedded within BMW
- Understanding
  - Talking/Observing
  - Focus groups
  - Analyzing previous tools
  - Reading
- Abstracting
- Deriving design requirements
2. Design, implement, deploy

4 month

- iterative paper prototyping
- agile software development
  - 3 lead users (engineers)
  - 6 deployed releases
- usability engineering
  - domain experts
  - HCI students
3. Summative Evaluation

2 month

- field study
  - 7 engineers
  - 5 weeks
- think aloud study
  - 10 engineers
  - ~1 hour each session
- adoption
  - 15+ users, 3 month post-study
4. Reflection

3 month

- revisit abstractions
- relate to other design studies
- write up
Summary
SUMMARY

Contributions

1. New network task and data abstractions

• radically different from previous work (Social Networks)
SUMMARY

Contributions

1. New network task and data abstractions

2. Fully validated design of RelEx
   - validated along the entire design cycle
   - first post-deployment study of a matrix view
   - supported target user needs (better/faster, entirely new possibilities)
   - adoption
THANK YOU!

RelEx
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