

## RELEX

Visualization for Actively Changing Overlay Network Specifications

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Nested	Mode
Focus	

doma	in problem characterization	$\overline{}$
da	ata/task abstraction	
	visual encoding/interaction	-
	algorithm	

Munzner, InfoVis 2009

![](_page_1_Figure_4.jpeg)

data/task abstraction	domain problem characterization	
visual encoding/interaction	data/task abstraction	
algorithm	visual encoding/interaction	
	algorithm	

Munzner, InfoVis 2009

![](_page_2_Figure_4.jpeg)

# NETWORK VIS **Data and Tasks?**

#### What are network analysts doing?

### NETWORK VIS Data and Tasks?

# What are network analysts doing? Social Network Analysis!

![](_page_4_Figure_2.jpeg)

MatrixExplorer

![](_page_4_Figure_4.jpeg)

SocialAction

![](_page_4_Figure_6.jpeg)

![](_page_4_Picture_8.jpeg)

#### I. Find clusters

![](_page_5_Figure_2.jpeg)

# Find clusters Find high-degree nodes

![](_page_6_Picture_2.jpeg)

Find clusters
 Find high-degree nodes
 Find bridge nodes

![](_page_7_Picture_2.jpeg)

Find clusters
 Find high-degree nodes
 Find bridge nodes
 Understand temporal dynamics

![](_page_8_Picture_2.jpeg)

### SOCIAL NETWORKS Abstract Data

#### Single (directed) graph

![](_page_9_Picture_2.jpeg)

### SOCIAL NETWORKS Abstract Data

#### Single (directed) graph

# Node scalability challenge

![](_page_10_Picture_3.jpeg)

## Network Vis beyond Social Networks

## email, academic papers?

![](_page_11_Picture_2.jpeg)

## Network Vis What we did

![](_page_12_Picture_1.jpeg)

#### Design Study: In-car network engineering

![](_page_12_Picture_3.jpeg)

![](_page_12_Picture_4.jpeg)

![](_page_12_Picture_5.jpeg)

![](_page_13_Picture_0.jpeg)

#### **Radically different task and data abstractions**

![](_page_13_Figure_2.jpeg)

![](_page_13_Figure_3.jpeg)

<sup>1</sup> Borgatti (2005): Centrality and network flow. <sup>2</sup> Willinger (2009): Mathematics and the internet: A source of enormous confusion and great potential.

![](_page_13_Picture_6.jpeg)

#### Understanding diversity is crucial to ensure applicable research<sup>1,2</sup>

## Problem characterization and abstraction:

Data

#### DATA In-car Electronics

![](_page_15_Picture_1.jpeg)

![](_page_15_Picture_3.jpeg)

#### DATA ABSTRACTION Base: Physical Network

![](_page_16_Figure_1.jpeg)

#### DATA ABSTRACTION Base: Physical Network

![](_page_17_Figure_1.jpeg)

#### ~100 ECU (nodes)

#### 10-15 Bus systems (edges)

### DATA ABSTRACTION Overlay: Logical Network

![](_page_18_Figure_1.jpeg)

#### ~100 ECU (nodes)

### DATA ABSTRACTION Overlay: Logical Network

![](_page_19_Figure_1.jpeg)

#### ~100 ECU (nodes)

#### ~IOk signals (edges)

![](_page_20_Figure_1.jpeg)

![](_page_21_Figure_1.jpeg)

![](_page_22_Figure_1.jpeg)

~30k signal paths (edges)

![](_page_23_Figure_2.jpeg)

![](_page_23_Figure_4.jpeg)

#### Data Abstraction Differences

![](_page_24_Picture_1.jpeg)

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

![](_page_24_Picture_5.jpeg)

## - Simple (directed) graph

## Problem characterization and abstraction:

## TASK ABSTRACTION Mapping

![](_page_26_Figure_1.jpeg)

![](_page_26_Figure_3.jpeg)

# TASK ABSTRACTION Traffic Optimization

![](_page_27_Figure_1.jpeg)

![](_page_27_Figure_3.jpeg)

![](_page_27_Picture_4.jpeg)

### TASK ABSTRACTION External Change Requests

![](_page_28_Figure_1.jpeg)

![](_page_28_Picture_2.jpeg)

#### TASK ABSTRACTION Differences

![](_page_29_Picture_1.jpeg)

![](_page_29_Picture_2.jpeg)

#### Implement active changes

![](_page_29_Picture_4.jpeg)

![](_page_29_Picture_6.jpeg)

## Understand **passive** changes

## Low-leve 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? ...

-- engineer, BMW --

3

![](_page_31_Figure_6.jpeg)

![](_page_31_Figure_7.jpeg)

![](_page_31_Figure_8.jpeg)

![](_page_32_Figure_1.jpeg)

![](_page_32_Picture_2.jpeg)

#### complex queries

![](_page_33_Figure_2.jpeg)

simple queries 2-way relations

![](_page_33_Figure_4.jpeg)

34

![](_page_33_Picture_5.jpeg)

![](_page_33_Picture_6.jpeg)

![](_page_34_Figure_0.jpeg)

#### complex queries

![](_page_35_Figure_2.jpeg)

Unsupported need: Logical Overview

#### simple queries

![](_page_35_Figure_5.jpeg)

36

![](_page_35_Picture_6.jpeg)

![](_page_35_Picture_7.jpeg)

![](_page_35_Figure_8.jpeg)

![](_page_35_Picture_9.jpeg)

![](_page_36_Figure_0.jpeg)

111

50 Signale >= 100 Signale

![](_page_37_Figure_0.jpeg)

![](_page_37_Figure_1.jpeg)

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50 Signale >= 100 Signale

## RELEX: Logical Overview

![](_page_38_Figure_1.jpeg)

![](_page_39_Figure_0.jpeg)

Filter löschen		Auswahl löschen
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## RELEX: Logical Overview

![](_page_40_Figure_2.jpeg)

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Beziehungen zwischen Steuergeräten

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50 Signale >= 100 Signale

## RELEX: **All Path of** a Signal

	SIGNAL PAT
Node-	link for path
IF-CAN	Vis Guidelin
	Def A-C AN R-C AN System 1 Dedy -CAN
	Beziehungen zwischen Steuergeräten

![](_page_41_Figure_5.jpeg)

![](_page_41_Figure_7.jpeg)

Filter löschen							
					🗖 🗖 Beziehungen	zwischen Steuergerä	iten
Image: Steuergeräte       Signale       Filter       Leg	sende Suche	Signalpfad XX	SF-CAN			M Su Cu	
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Daten_EWS_EGS_3	CAS, DME1 🚽				43 1 Signal	10 Signale	

#### RE STUFF: **ort of ent Practices**

![](_page_42_Figure_2.jpeg)

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50 Signale >= 100 Signal

## MORE STUFF: Cross-Network Relations

![](_page_43_Figure_2.jpeg)

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50 Signale >= 100 Signale

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Within-bus

#### **Between-bus**

![](_page_46_Figure_3.jpeg)

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RexRay

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introvert vs. extrovert

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introvert vs. extrovert

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## 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

![](_page_50_Picture_9.jpeg)

# 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

![](_page_51_Figure_8.jpeg)

# 3. Summative Evaluation 2 month

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

![](_page_52_Picture_9.jpeg)

# **4. Reflection**3 month

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

![](_page_53_Picture_4.jpeg)

## Summary

### SUMMARY Contributions

#### I.New network task and data abstractions

• radically different from previous work (Social Networks)

![](_page_55_Picture_3.jpeg)

![](_page_55_Picture_4.jpeg)

#### **ctions** works)

#### SUMMARY Contributions

I. 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

![](_page_56_Figure_8.jpeg)

![](_page_57_Figure_0.jpeg)

## RELEX

Visualization for Actively Changing Overlay Network Specifications

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