Efficient development of Statechart models
A comparative study

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Christian-Albrechts-Universität zu Kiel

Overview

Graphical Modeling—A Good Thing!

> *Today, we see with some surprise that visual notations for synchronous languages have found their way to successful industrial use with the support of commercial vendors. This probably reveals that building a visual formalism on the top of a mathematically sound model gives actual strength to these formalisms and makes them attractive to users.*
>
> Benveniste et. al.

Albert Benveniste, Paul Caspi, Stephen A. Edwards, Nicolas Halbwachs, Paul Le Guernic, and Robert de Simone.
The Synchronous Languages Twelve Years Later.
In *Proceedings of the IEEE, Special Issue on Embedded Systems*, volume 91, pages 64–83, January 2003.

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Observation 3:

- Graphical models already work well to visualize complex structures
- . . . but are still limited for visualizing complex *behaviors*!

Our Approach

The vision:

- Provide flexible, alternative views of system under development (SUD)
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Our experimental platform:

- Kiel Integrated Environment for Layout

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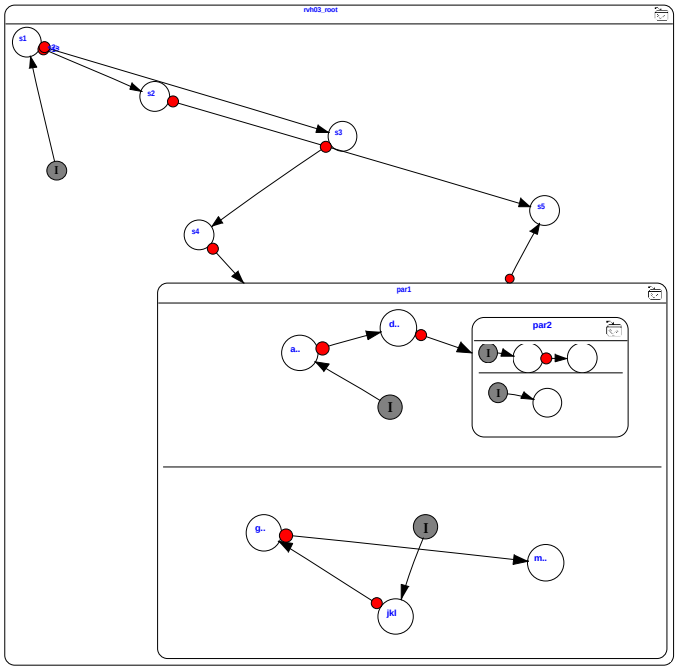
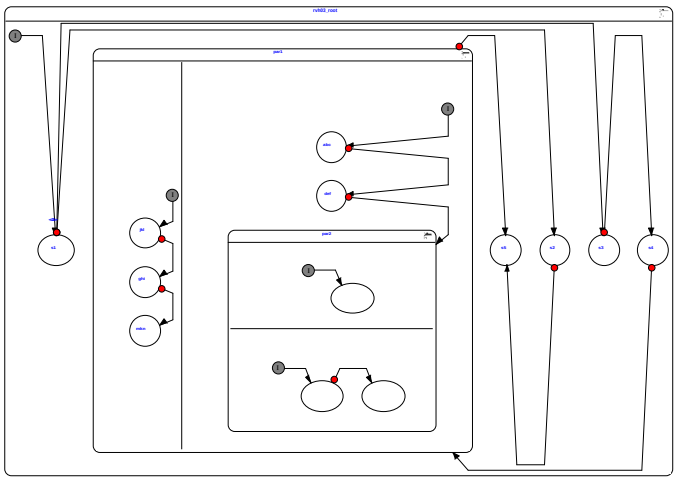


(a) Original Layout



(b) After Auto-layout

KIEL—Current State

Automatic Layout:

- Employ various strategies (GraphViz + others)
- Use generic hierarchy wrapper

Model creation:

- Import from Esterel Studio, ArgoUML, Stateflow
- KIEL macro editor
- KIT Editor
- Synthesis from Esterel *LCTES'06*
- Robustness checking *MARTES'06*
- Cognitive experiments *MODELS'07*

Simulation:

- Use dynamic statecharts *DATE'06*

Overview

Creating Graphical Models

State of the Practice

- WYSIWYG editors to create graphical models
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The Problem

- Non-linearity — Text: 1-D, Graphics: 2-D
- Context entanglement — Transitions, State hierarchy, concurrency

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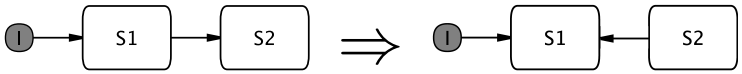
2. Macro-based modeling
   - Employs Statechart production rules
   - Incremental synthesis
   - Also referred to as "structure-based"
3. Text-based modeling
   - Modeler uses textual language
   - Model synthesis from textual description

Macro-Based Modeling

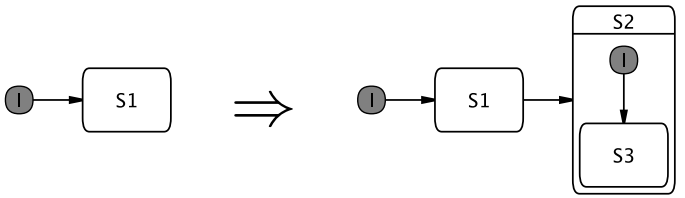
- Identified nine main Statechart editing schemata
- Three categories: 1. *creation*, 2. *modification*, 3. *deletion*

(a) Insertion of a simple successor state.

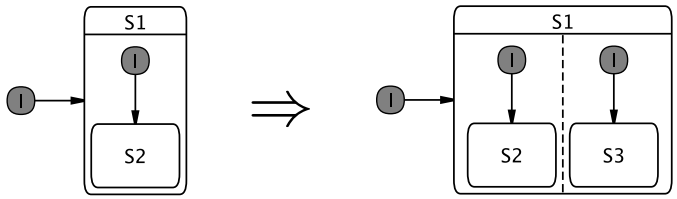


(b) Modification of transition direction.

(c) Deletion of a Statechart element.

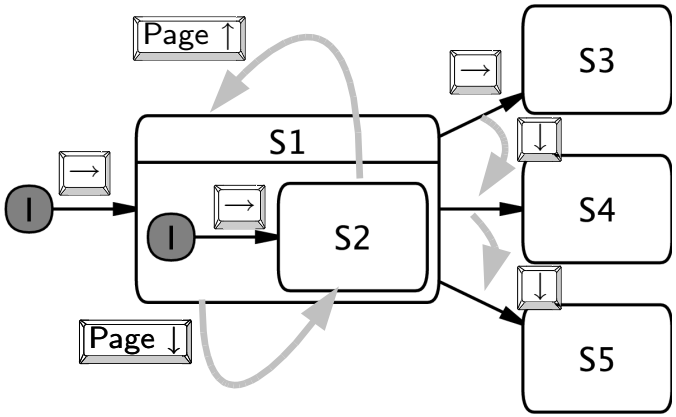


(d) Insertion of hierarchical successor state.

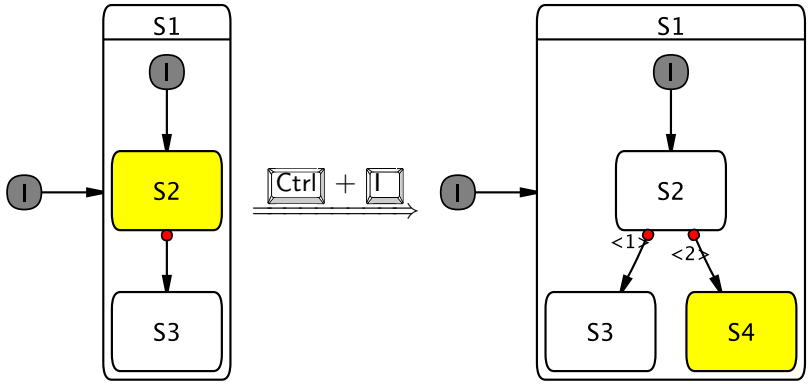


(e) Insertion of a parallel region.

Macro-Based Modeling



(a) Navigation with key strokes.



(b) Example of applying the "insert simple successor state" schema.

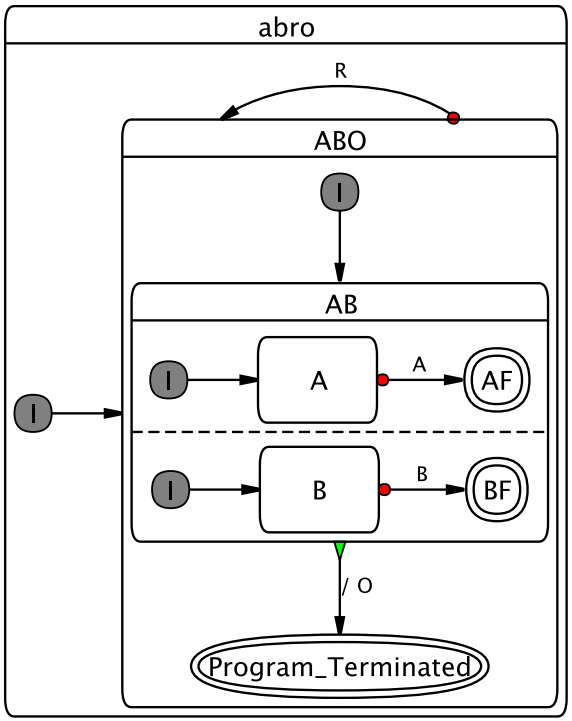
Text-Based Modeling

KIel Statechart extension of doT:

- Implicit declarations in *dot*,
- Hierarchy construction in *Argos*,
- Orthogonal construction in *Esterel*, and
- Ability to describe different Statechart dialects

```
statechart abro[model="Esterel Studio";version="5.0"]{
 input A;
 input B;
 input R;
 output O;
 {
  ->ABO;
  ABO{
   AB{
     ->A;
     A->AF[type=sa;label="A"];
     AF[type=final];
    ||
     ->B;
     B->BF[type=sa;label="B"];
     BF[type=final];
   };
   ->AB;
   AB->Program_Terminated[type=nt;label="/ O"];
   Program_Terminated[type=final];
  };
  ABO->ABO[type=sa;label="R"];
 };
};
```

(a) KIT description representation.



(b) SSM representation.

Visualizing Complex Behaviors

- View of single chart rarely suffices—need to see several active charts at once
- Set of active charts changes dynamically
- Keeping active charts in foreground requires significant additional user effort during simulation

The Problem:

- Concurrency
- Fixed level of detail
- Spreading system across several charts (windows) aids model creation and maintenance
  . . . but results in fragmented overall picture

Dynamic Charts

- Introduce different system views, defining
  - visible parts of the system
  - visible level of detail
- Present dynamically changing views dependent on
  1. Simulation state
  2. User requests
- A dynamic extension to semantic focus-and-context representation

Oliver Köth.
Semantisches Zoomen in Diagrammeditoren am Beispiel von UML.
Master's thesis, Friedrich-Alexander-Universität Erlangen-Nürnberg, 2001.

Overview

The Experiment

Goals

1. Investigation of differences in editing using an WYSIWYG Statechart editor, the KIEL macro editor, and the KIT editor
2. Comparison of the readability of Statechart layouts created by the KIEL layouter and other Statechart layouts

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Subjects

- Graduate-level students attending the lecture "Model-Based Design and Distributed Real-Time Systems" in the Winter Semester 2006/07
- Conducted two series of experiments, at beginning and end of semester
  1. Novices (24 subjects): basic knowledge concerning Statecharts
  2. Advanced (19 subjects): some practical experience

Experiment 1: Statechart Creation

Hypotheses

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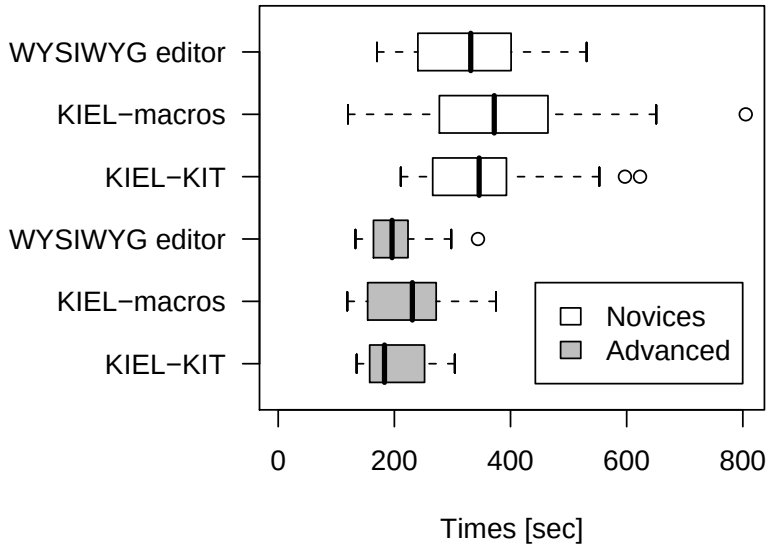

Distribution of times for creating a new Statechart

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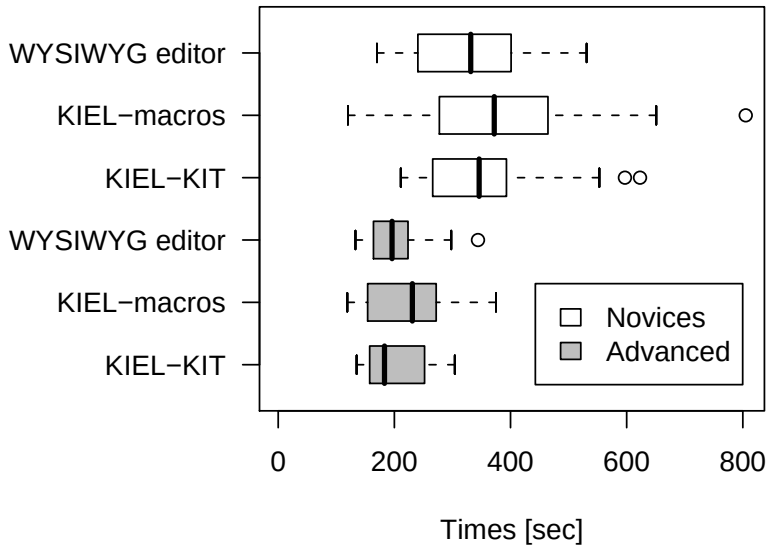

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Experiment 1: Statechart Creation

Hypotheses

1. Novices will need less time to create a Statechart using the WYSIWYG editor.
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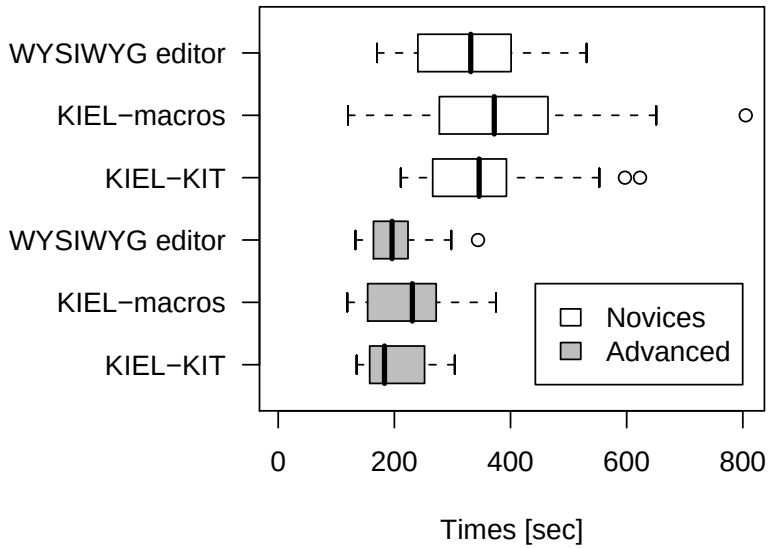
2. Advanced will need less time using the KIT editor.
   Weakly confirmed.

Results



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Statechart modification using the KIT editor or the KIEL macro editor is faster than using the WYSIWYG editor.

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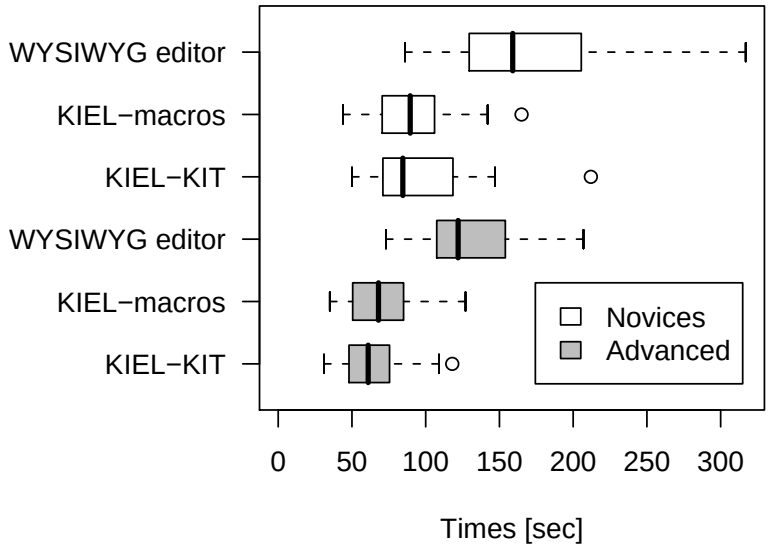

Distribution of times for modifying an existing Statechart

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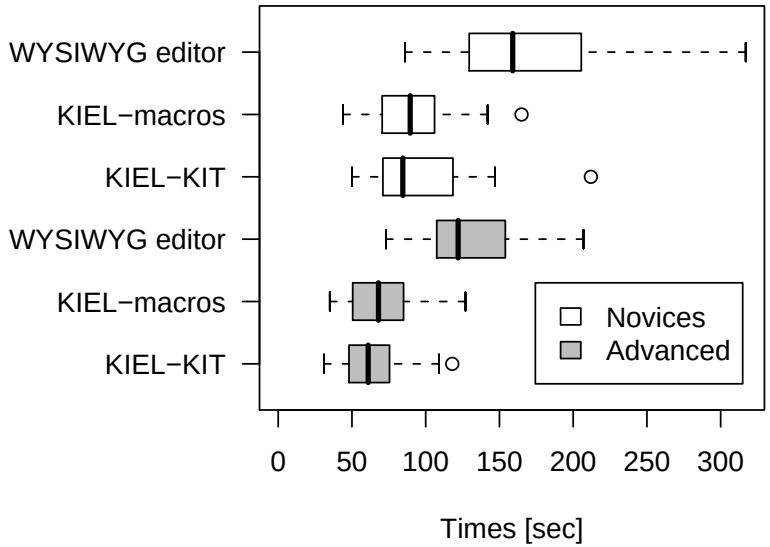

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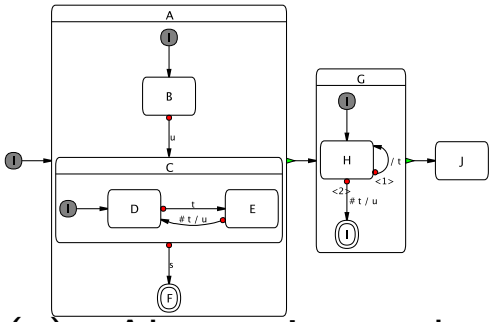
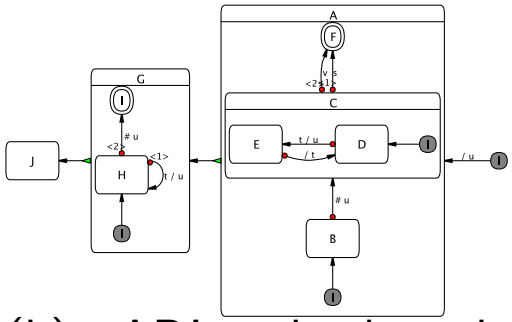
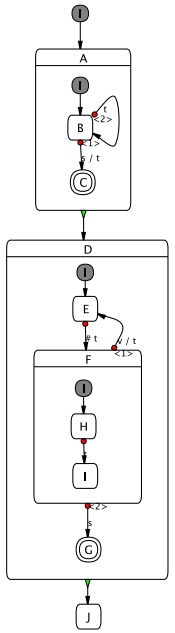
Statechart layout alternatives



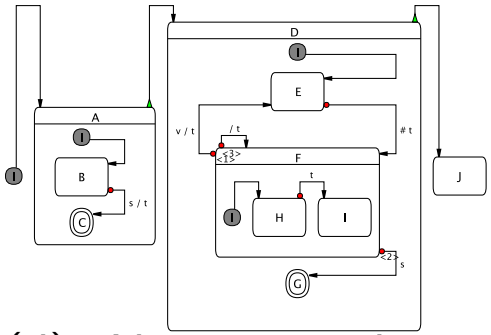
(a) Alternating dot layout (ADL)



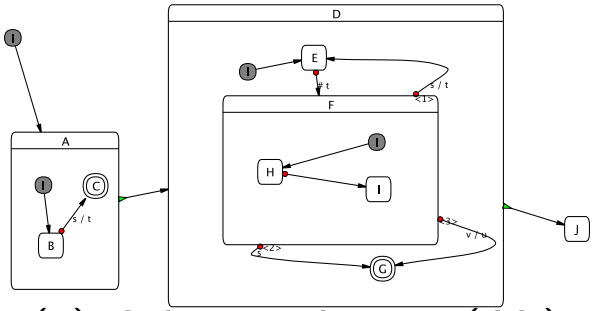
(b) ADL backwards (ADBL)



(c) Linear layer layout (LLL)



(d) Alternating linear layout (ALL)



(e) Arbitrary layout (AL)

Experiment 3: Statechart Aesthetics

Hypothesis

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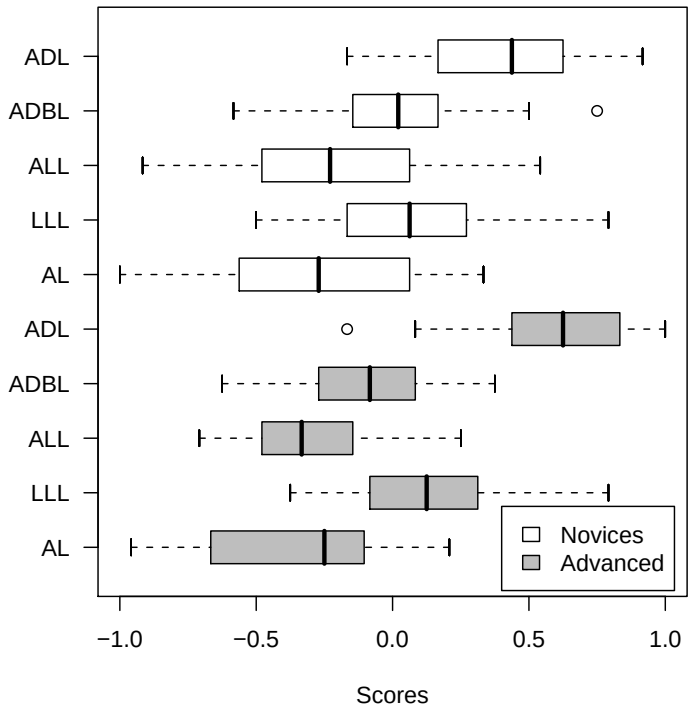

Distribution of subjective Statechart layout scores

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Confirmed—and slightly more pronounced for advanced users.

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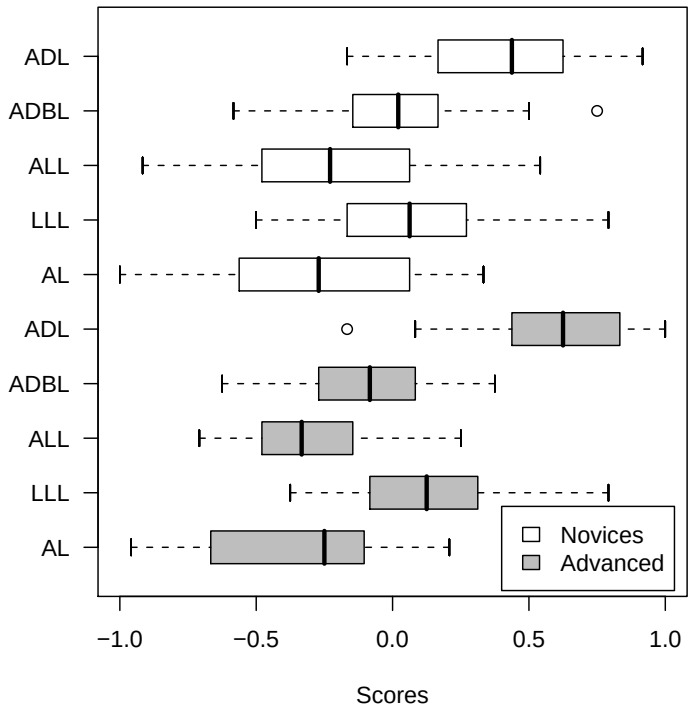

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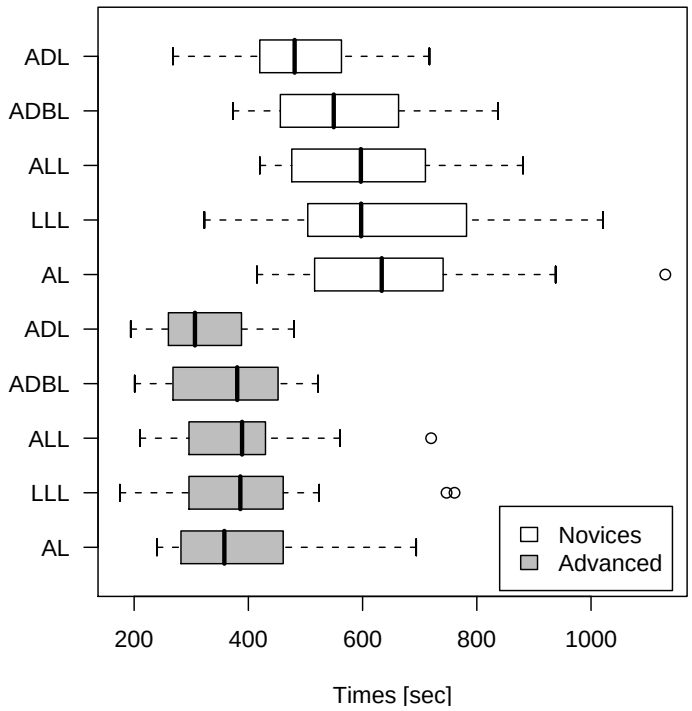

Distribution of Statechart comprehension times

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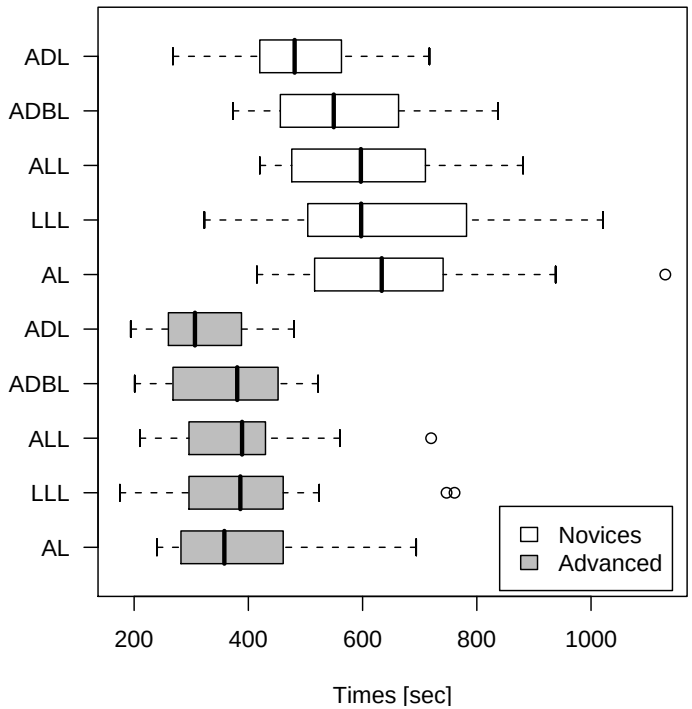

Distribution of Statechart comprehension times

Summary

- KIEL provides a platform for experimenting with the pragmatics of graphical modeling
- Have conducted experiments within the classroom
- Most, but not all, hypotheses were confirmed
- Overall results indicate usefulness of editing alternatives to the classical WYSIWYG paradigm
- Still missing: study with more complex, real-world designs

Outlook

Are transitioning to new generation of KIEL

- Make visual information truly first class citizen
- Incorporate data flow
- Make it as open as possible
- Many more ideas . . .

Open questions

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- What about "dynamic" data flow?
- What platform to use? (Eclipse? Ptolemy? . . .)

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`www.informatik.uni-kiel.de/en/rtsys/kiel/`

Thanks! Questions or comments?