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Technical Symposium on Computer Science Education

InfoTraffic – Teaching Important Concepts of Computer Science and Math through Real–World Examples

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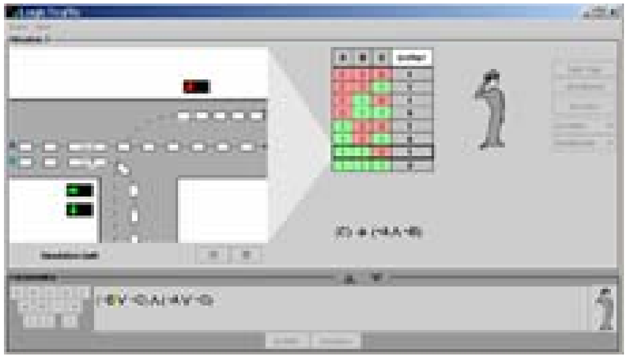
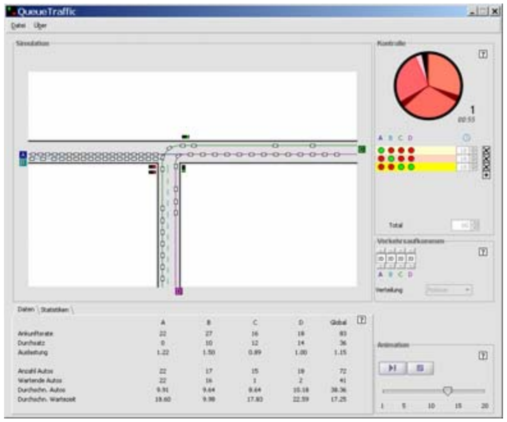
Project InfoTraffic

InfoTraffic is a **collection of learning environments** for teaching important concepts of computer science and math.

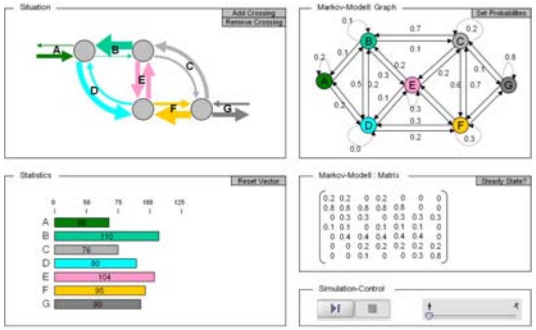
– Motivation: Abstract concepts are easier to introduce with the help of real-world examples



LogicTraffic

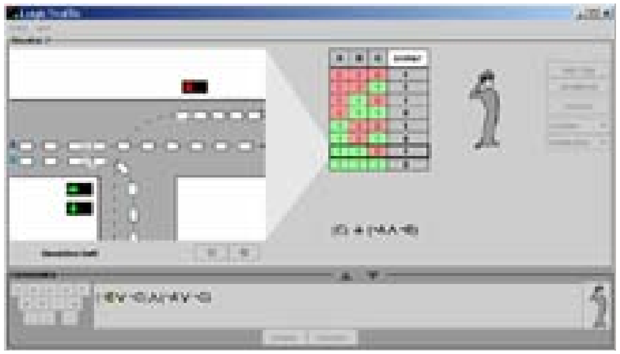


QueueTraffic



(DynaTraffic)

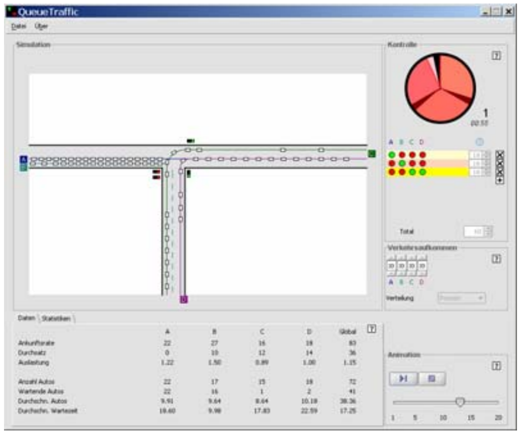
LogicTraffic & QueueTraffic



LogicTraffic: propositional logic

- Truth tables, operators, normal forms, equivalence…

➔Make intersections safe!



QueueTraffic: queuing theory

- Arrival rate, throughput…

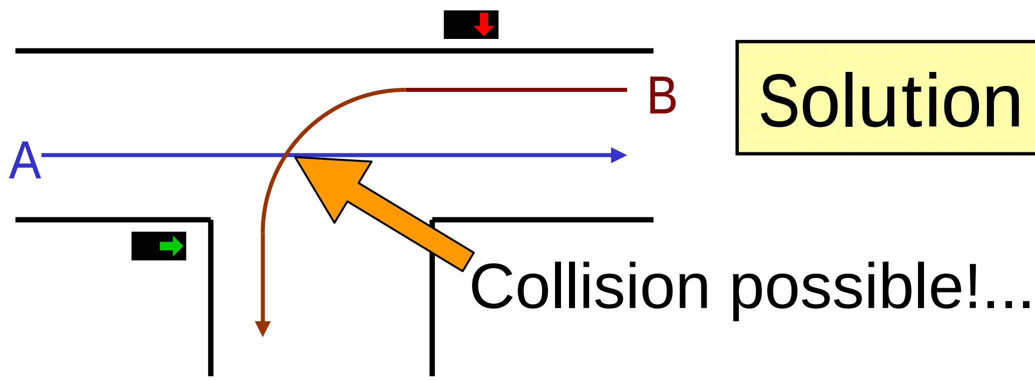
➔Simulation & analysis of traffic jams!

⇨Freely available online along with teaching material

⇨Used and tested many times in Swiss high schools and teacher education courses

LogicTraffic: Propositional Logic at Intersections

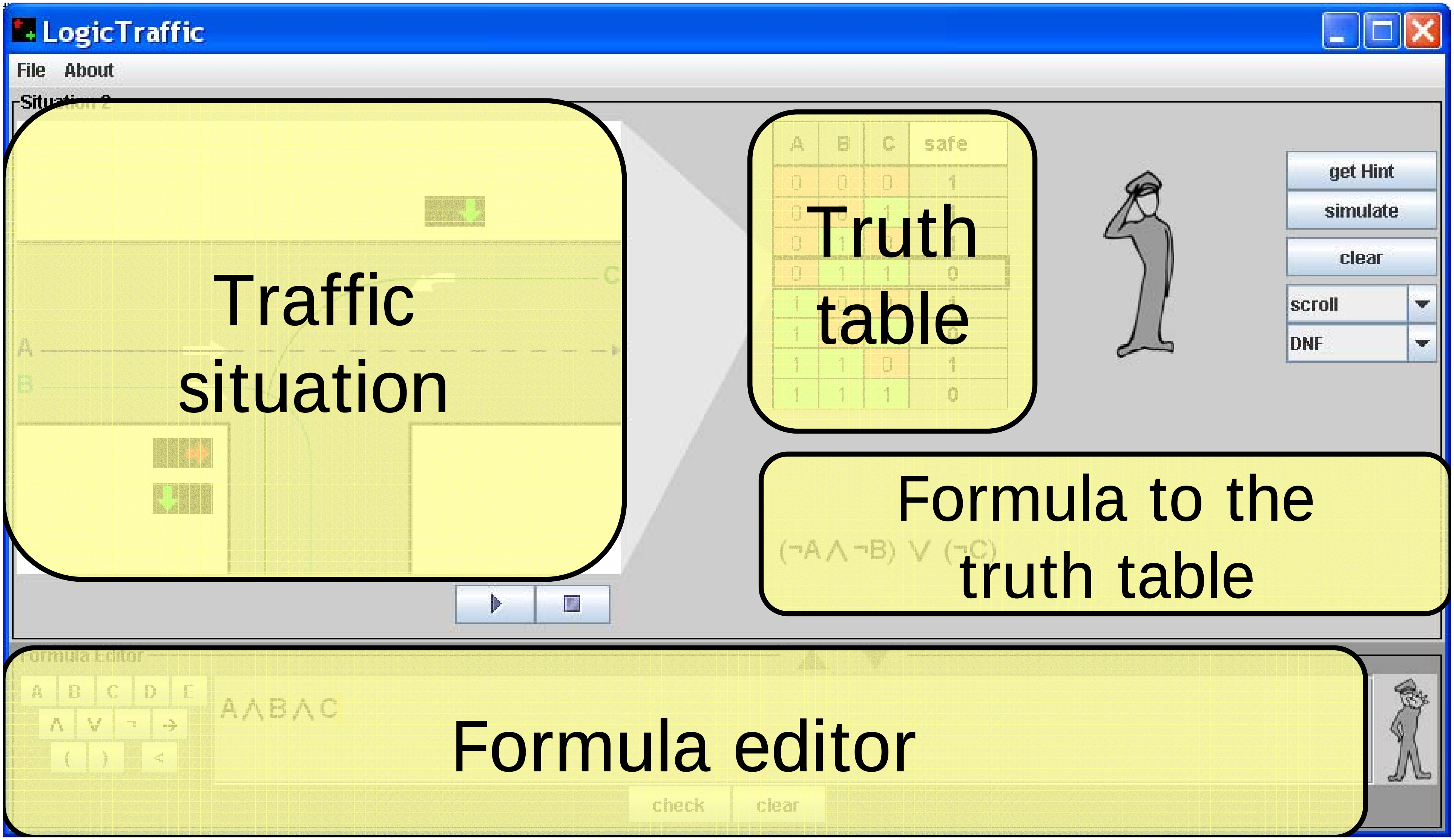
Requirement: **no collisions!**



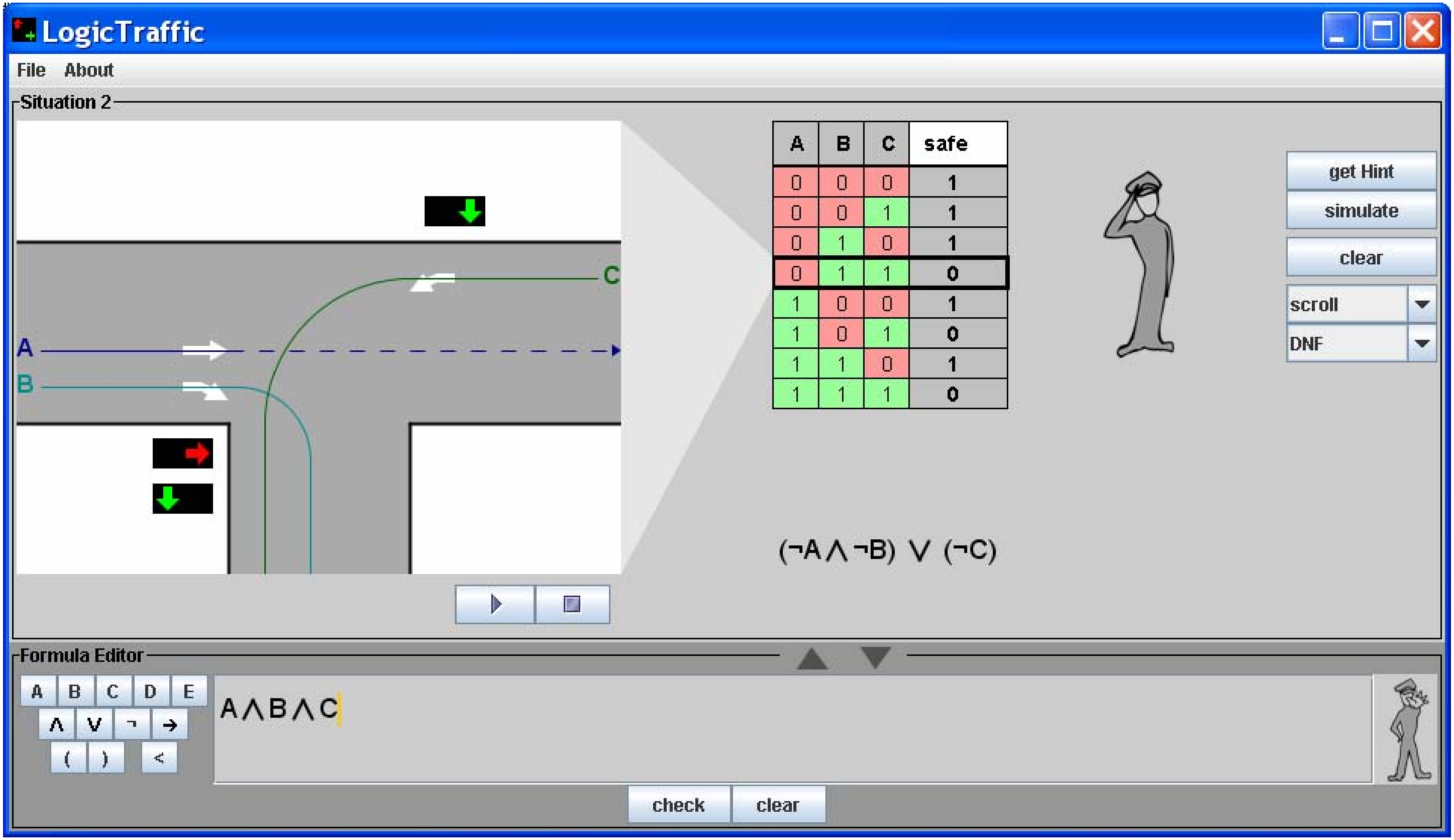
Solution here e.g.: $\neg A \vee \neg B$

- What must hold that no collisions are possible?
- How can this be specified with propositional logic?

LogicTraffic: GUI



LogicTraffic: Short Demo



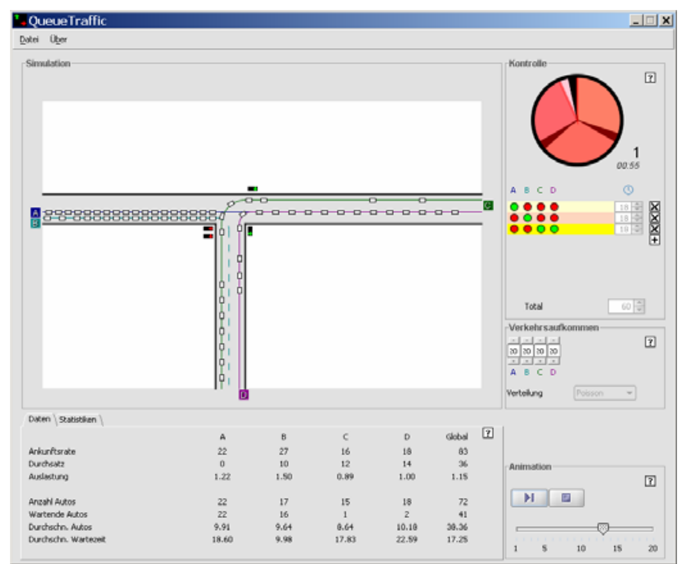
QueueTraffic: Queuing Theory at Intersections

Simulation and analysis of queues at traffic intersections

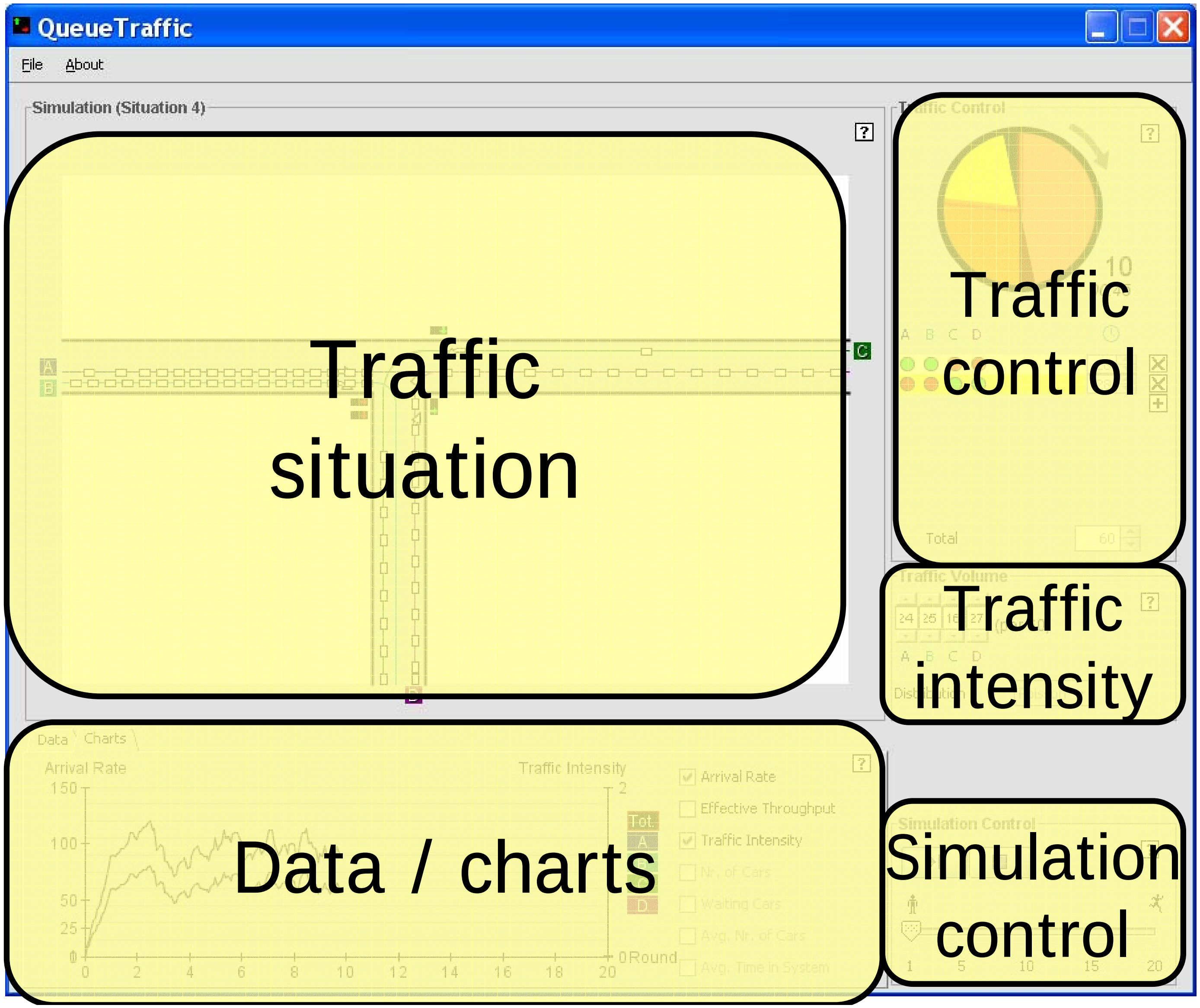
- Variation of parameters
- Observation of outcome

Introduction to concepts of queue theory

- Arrival rate
- Throughput
- Utilization and congestion
- Poisson vs. uniform distribution
- …



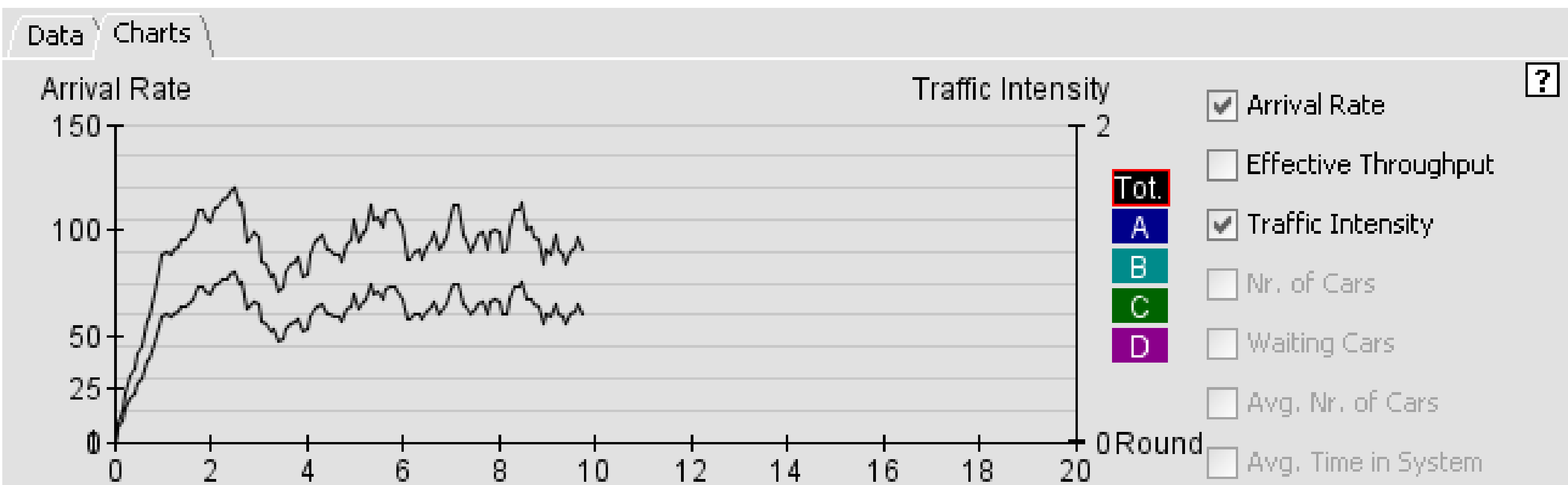
QueueTraffic: GUI



QueueTraffic: Data and Charts

Data | Charts

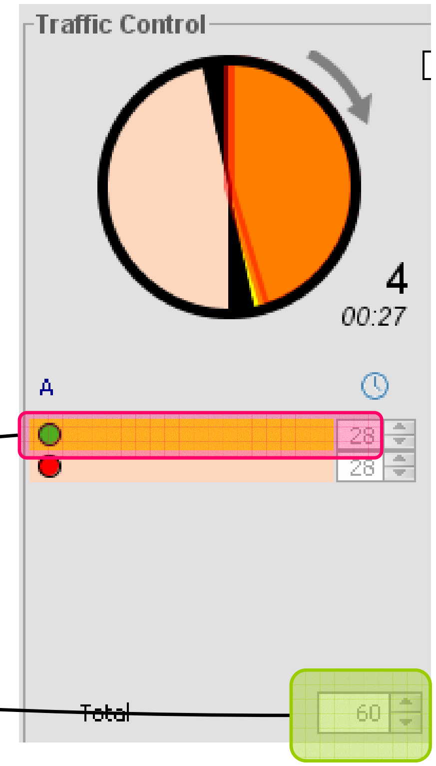
	A	B	C	D	Global
Arrival Rate (per Round)	28	25	13	26	91
Effective Throughput (per Round)	27	26	15	27	95
Traffic Intensity	1.00	0.89	0.46	0.93	0.81
Nr. of Cars	16	25	11	61	113
Waiting Cars	14	25	0	45	84
Avg. Nr. of Cars	16.67	22.99	10.60	40.57	90.83
Avg. Time in System	12.64	14.70	29.19	14.82	17.84

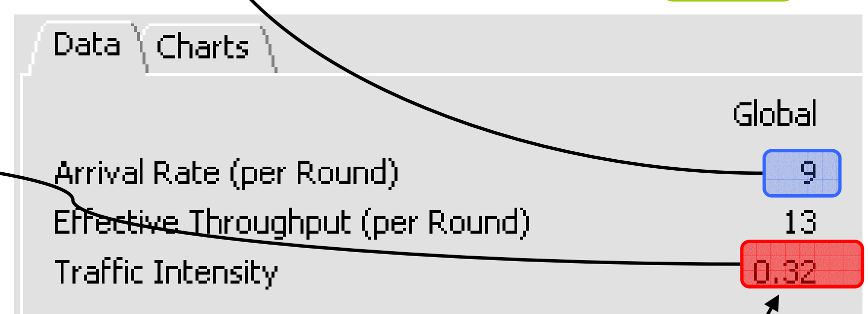


QueueTraffic: Sample Calculations

- **Arrival rate:**
  - λ = **10 car / 60 s**
- **Effective throughput:**
  - μ_e = **9 cars / 60 s**
- **Theoretical throughput:**
  - μ_t = **(28 s / 60 s) * (1 car / 1 s)**
    = 28 cars / 60 s
- **Utilization:**
  - $\rho = \lambda / \mu_t$ **!!!**
    = (10 cars / 60 s) / (28 cars / 60 s)
    = 0.36

calculated!





simulated!
(counted)

Main Didactical Concepts

1. Choice of content

- Design of learning environment

- Use in class

1. Content: Fundamental Ideas

- Propositional logic and queuing theory are **fundamental ideas** according to [1]
  - Different applications
  - On different cognitive levels
  - Historically and in the longer perspective relevant
  - Connection to everyday language and actions

⇨ It's important and therefore worth the effort!

[1] A. Schwill. Fundamental ideas of computer science. EATCS-Bulletin, 53:274-295, 1994.

2. Design: Interactivity

- Schulmeister [4]: 6 levels of interactivity
  1. Display only
  2. Navigation
  3. Different representations
  4. Modification of parameters ⟸ QueueTraffic
  5. Construction of own objects
  6. Intelligent feedback ⟸ LogicTraffic

- Attractive for the „Nintendo Generation“ according to [5] (Animation, different possibilities for interaction)

[4] R. Schulmeister. Taxonomy of Multimedia Component Interactivity. A Contribution to the Current Metadata Debate. Studies in Communication Sciences. Studi di scienze della communicazione., 3(1):61-80, 2003.
[5] M. Guzdial and E. Soloway. Teaching the nintendo generation to program. Comm. of the ACM, 45(4):17-21, 2002.

2. Design: Different Representations

Three basic representations according to [2], supplemented by a virtual one by [3]

- Thinking: formal operation possible in different media

Symbolic - symbol

„tree“

Iconic - picture

Enactive - action

Virtual-enactive – simulated action

[2] J. S. Bruner, R. R. Oliver, and P. M. Greenfeld. Studies in Cognitive Growth. Wiley, New York, 1966.

[3] W. Hartmann, M. Naef, and R. Reichert. Informatikunterricht planen und durchführen. Springer, Heidelberg Berlin New York, 2006.

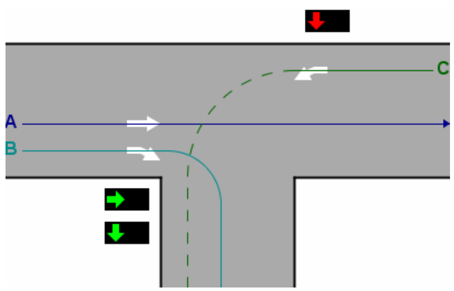
2. Representations in LogicTraffic

- Symbolic

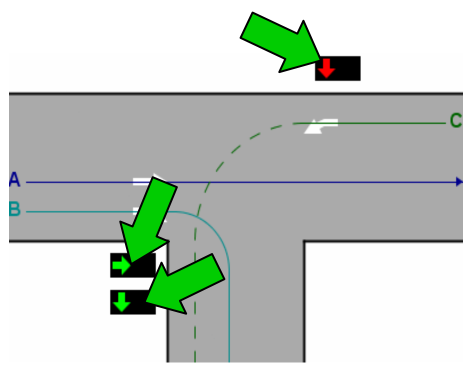
$$(\neg A \wedge \neg B) \vee (\neg C)$$

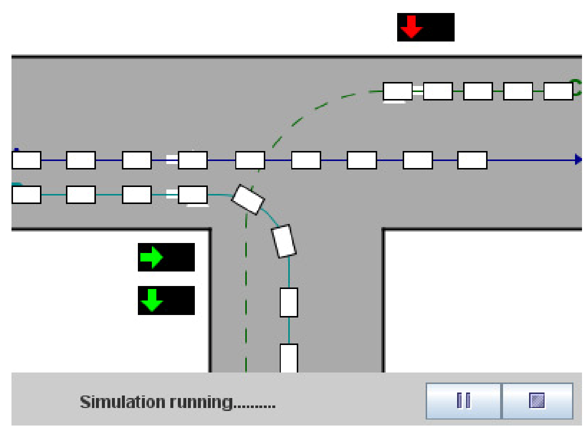
A	B	C	safe
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

- Iconic



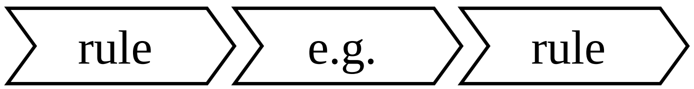
- Virtual-enactive



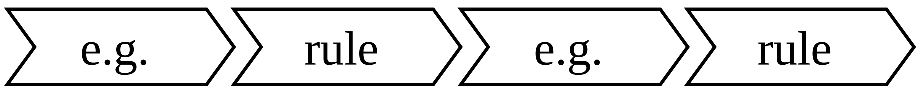


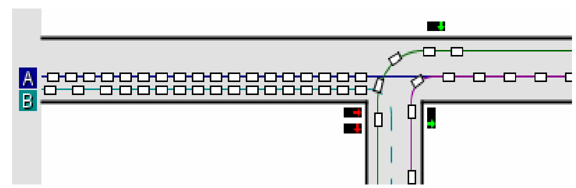
3. Use: eg-rule-eg-rule or Advance Organizer +

- Teaching often based on the rule-eg-rule technique [6]



- For abstract content better use eg-rule-eg-rule:



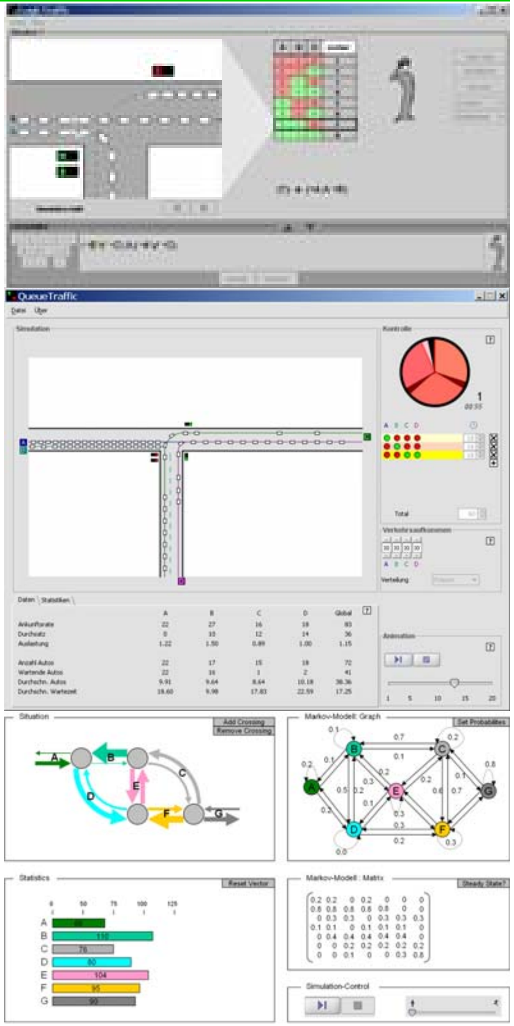
  – Introduce Queues as M/M/1 system or as  ?

- Different view: Extension of an advance organizer [7]
  – Not only begin with a summary and references to prior knowledge, but with an elaborate example known from everyday life.

[6] D. A. Bligh. What is the Use of Lectures? Penguin Books, 1972.
[7] D. P. Ausubel. The use of advance organizers in the learning and retention of meaningful verbal material. Journal of Educational Psychology, 51:267-272, 1960.

InfoTraffic – THE END

- **Underway: DynaTraffic**
  - Dynamic Systems, Markov chains



Remarks?

Questions?

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SW & teaching material: http://swisseduc.ch/compscience/infotraffic/

http://swisseduc.ch/compscience/infotraffic/