Verification of Message Sequence Charts

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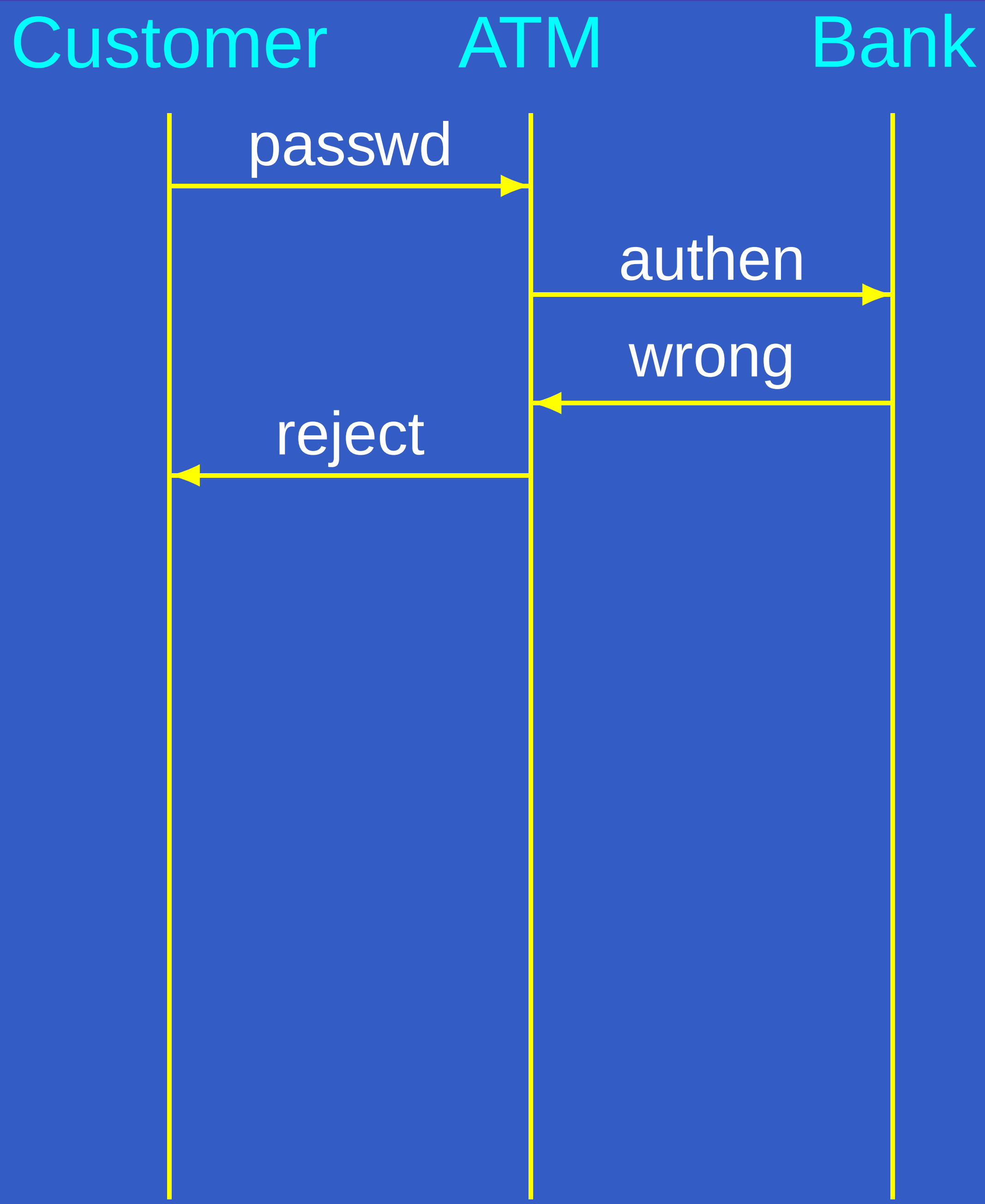
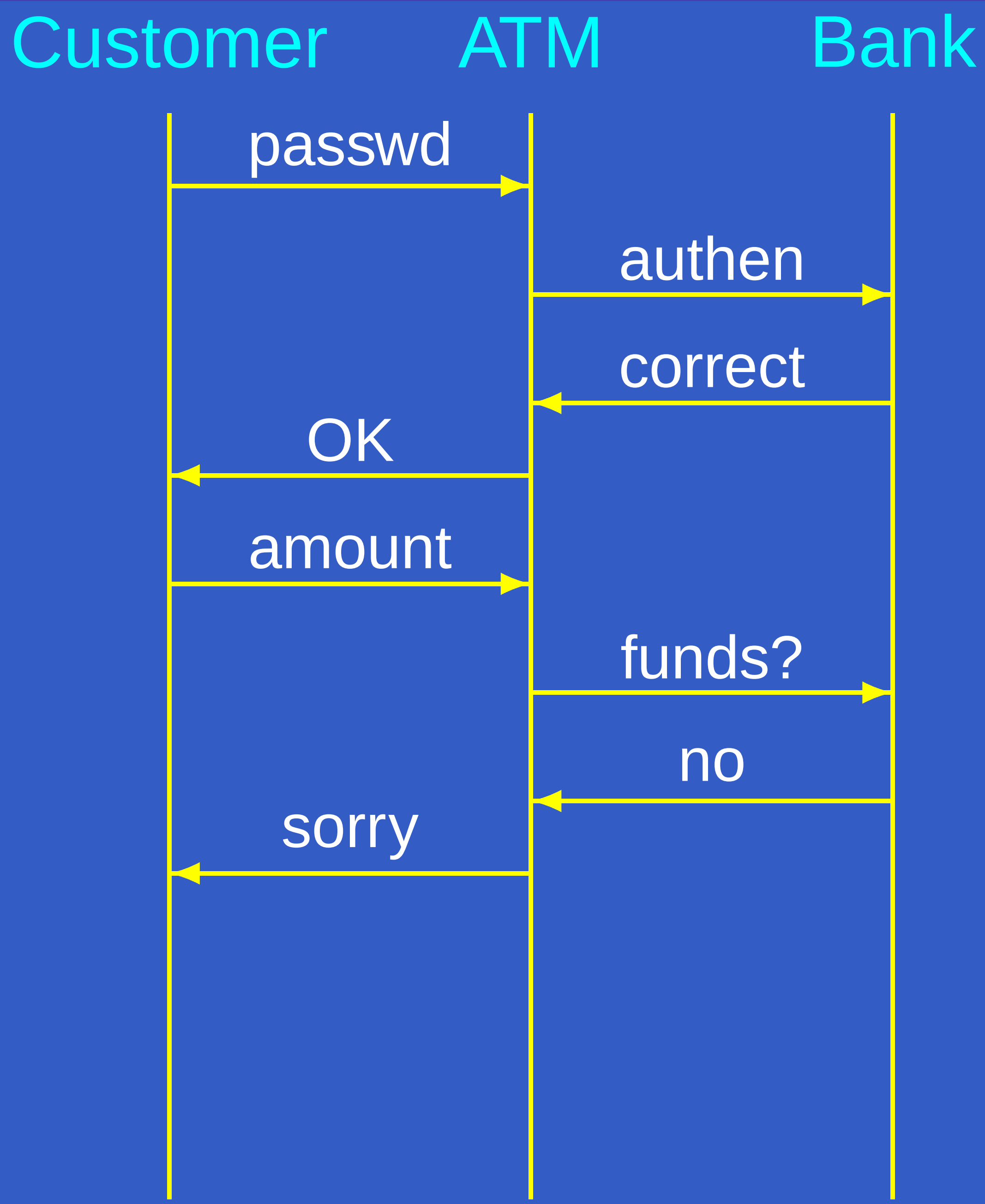
Scenarios

- A scenario describes a pattern of interaction
- Attractive visual formalism
- Telecommunications
  - Message sequence charts (MSC)
  - Messages sent between communicating agents
- UML
  - Sequence diagrams
  - Interaction between objects
    e.g., method invocations etc

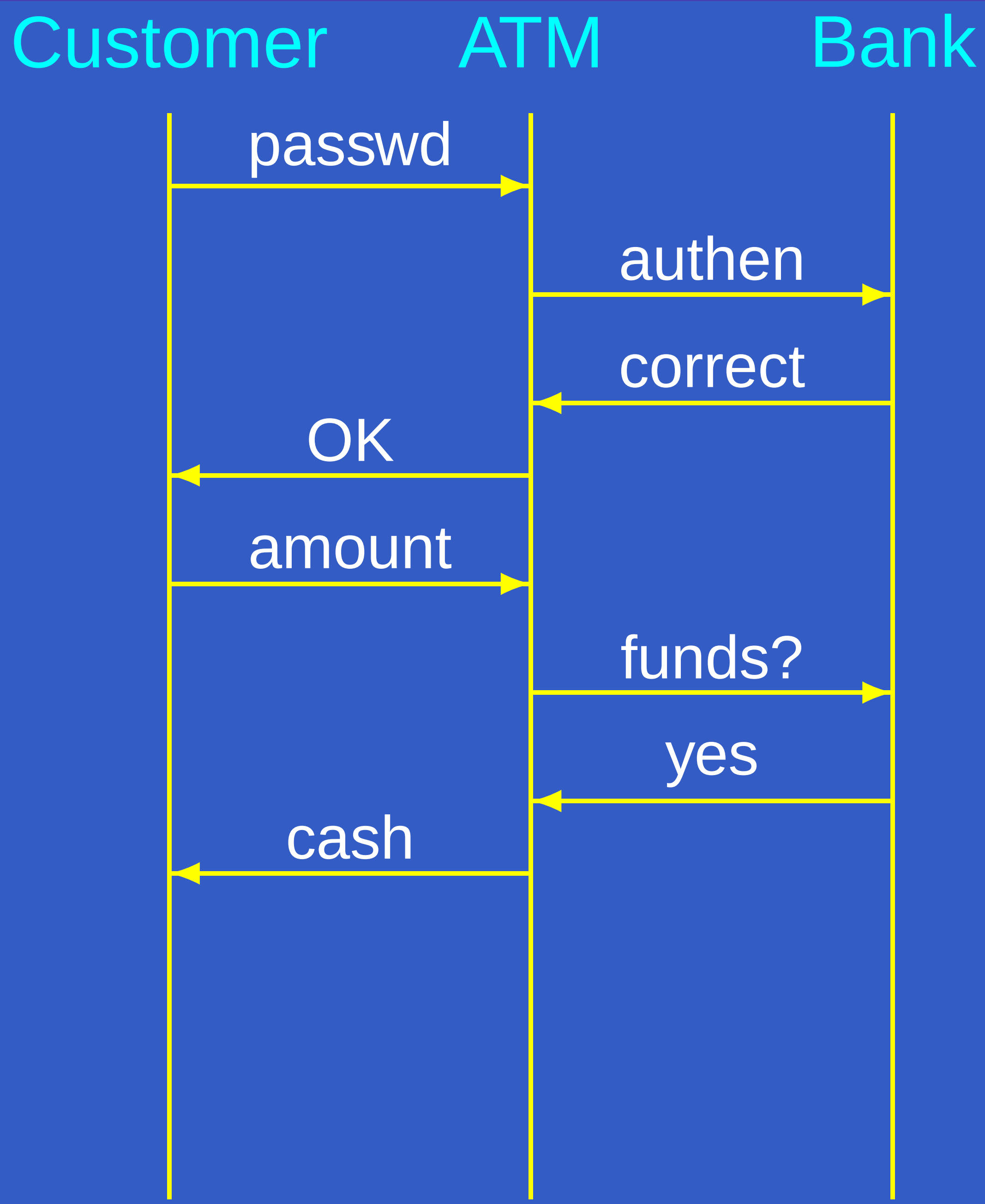
An ATM



An ATM

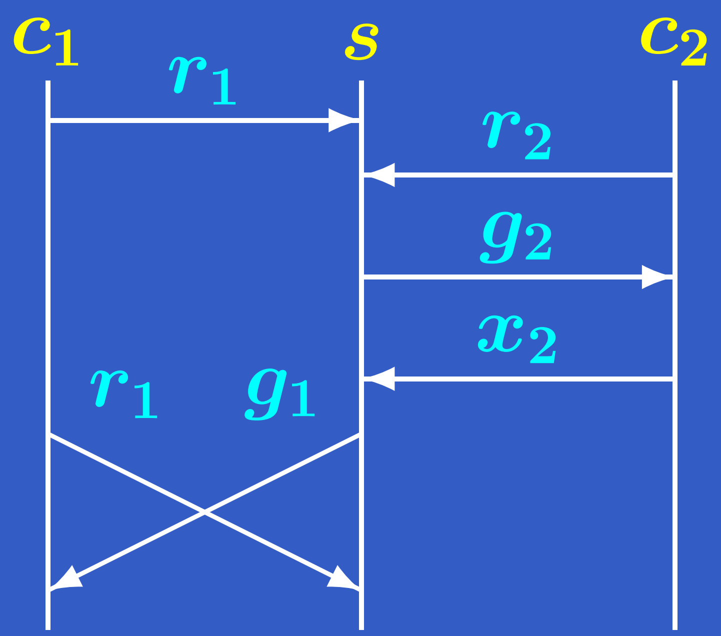

Customer
ATM
Bank
passwd
authen
correct
OK
amount
funds?
no
sorry

An ATM


Customer
ATM
Bank
passwd
authen
correct
OK
amount
funds?
yes
cash

Message sequence charts

Two clients and a server



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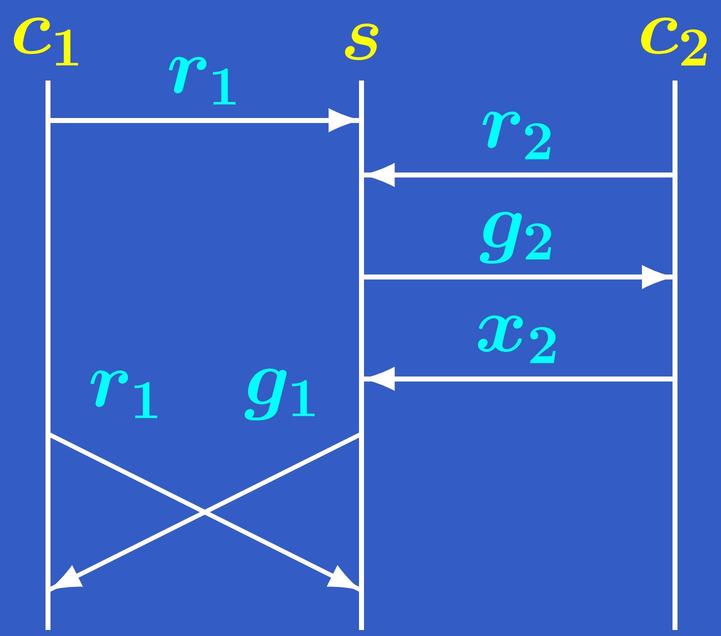

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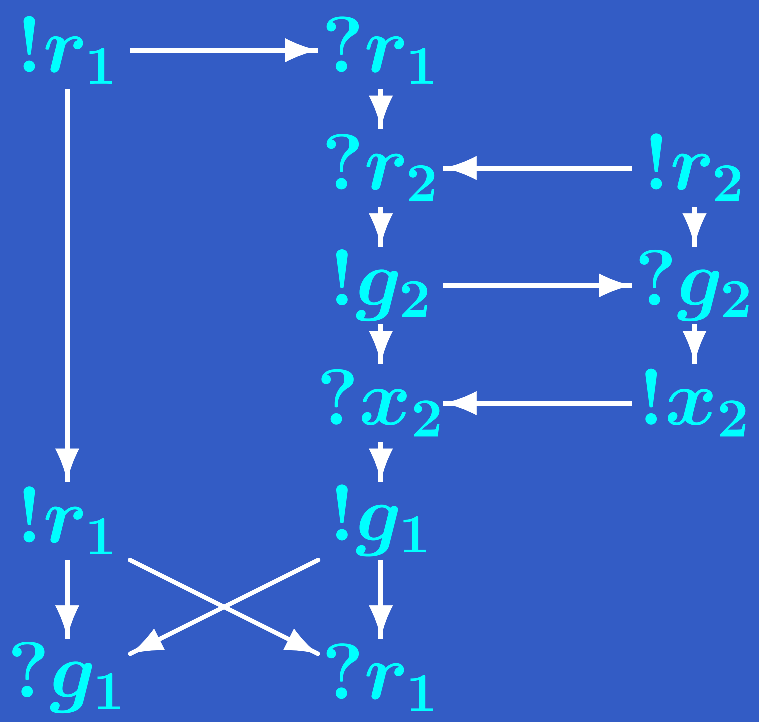

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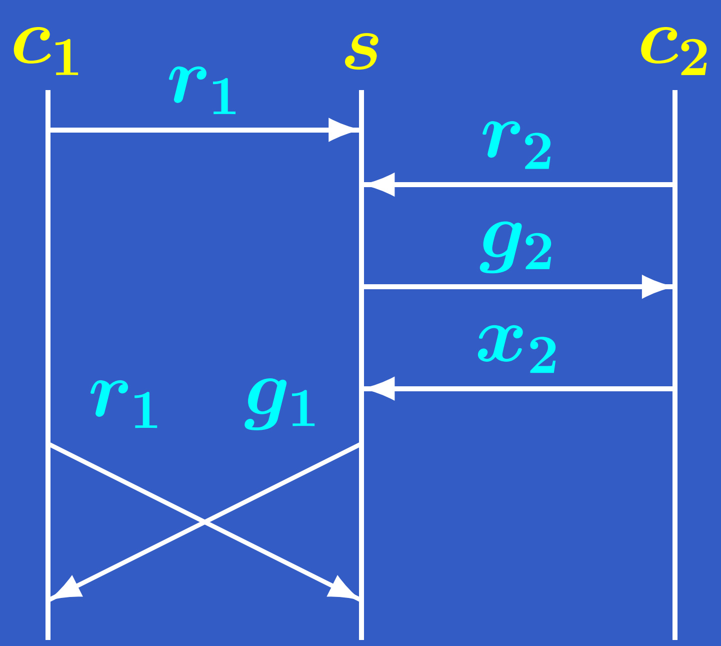

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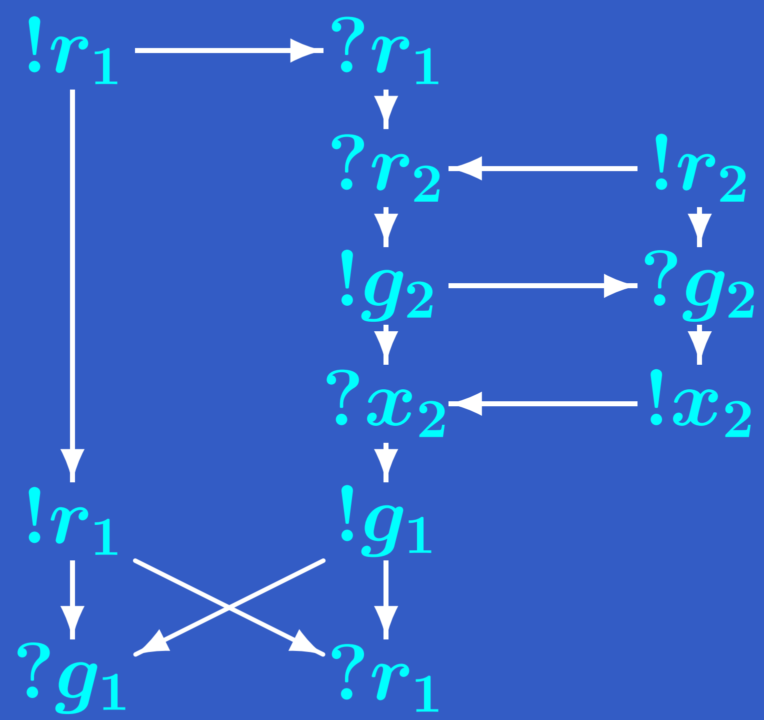

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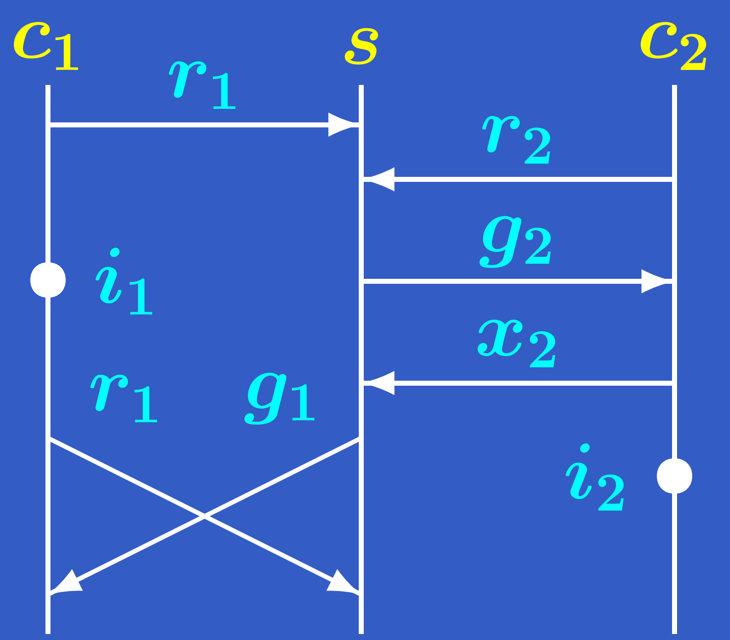

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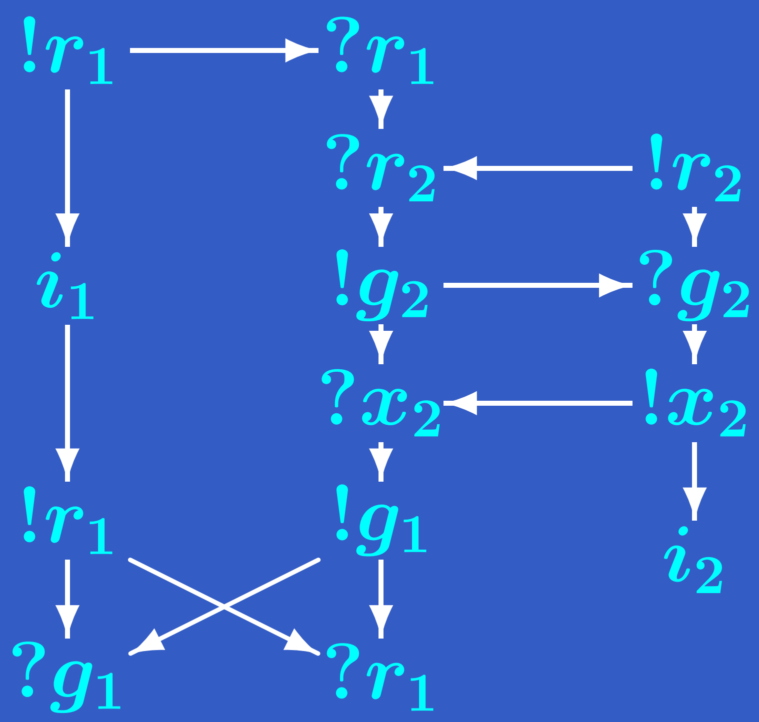

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Can add *internal* events, local to processes

Collections of MSCs

- Often need to specify a collection of scenarios
- Finite collection can be exhaustively enumerated
- Infinite collection needs a generating mechanism

High level MSCs (HMSCs)

- A finite state automaton
- Each state is labelled by an MSC
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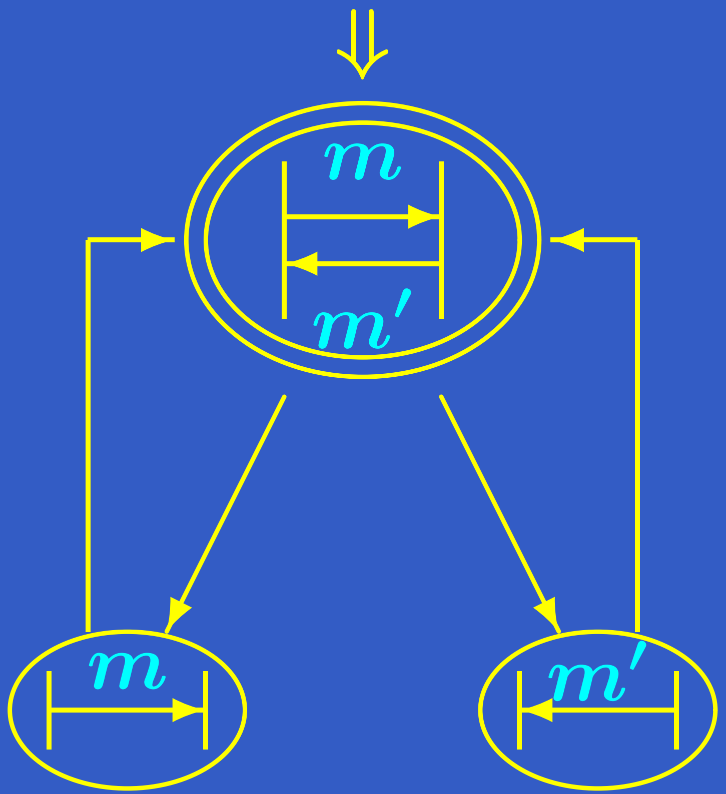

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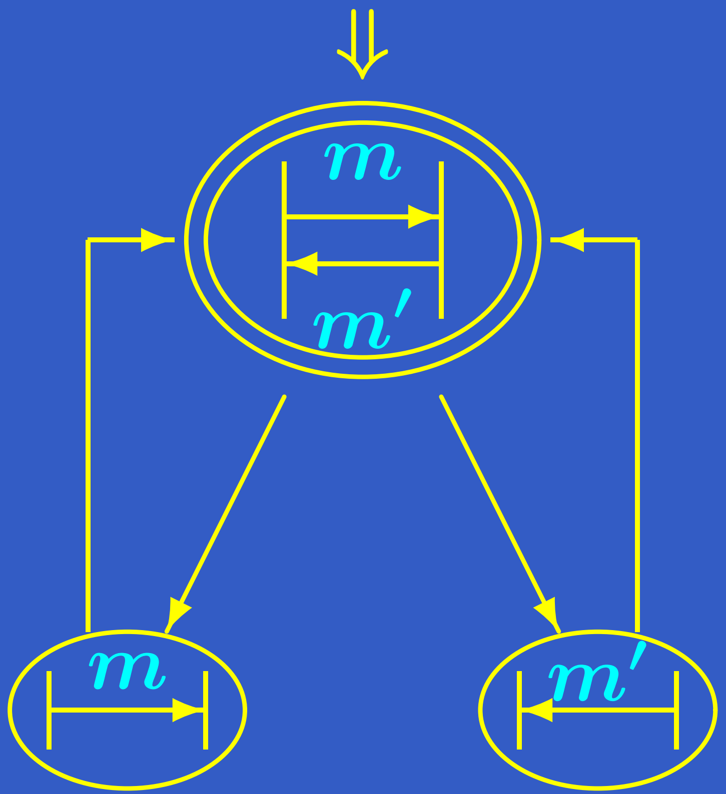

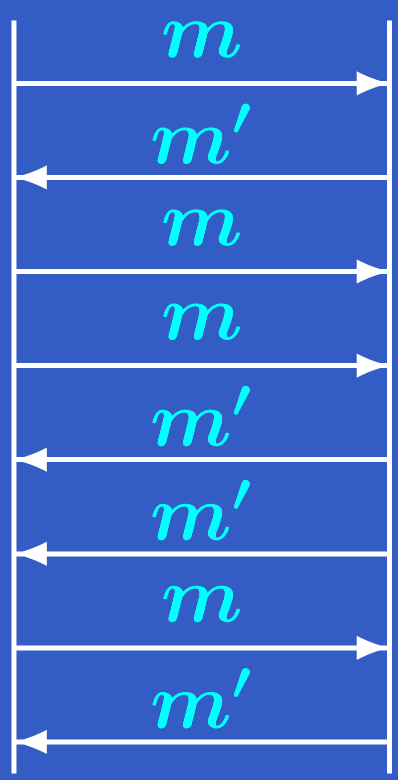

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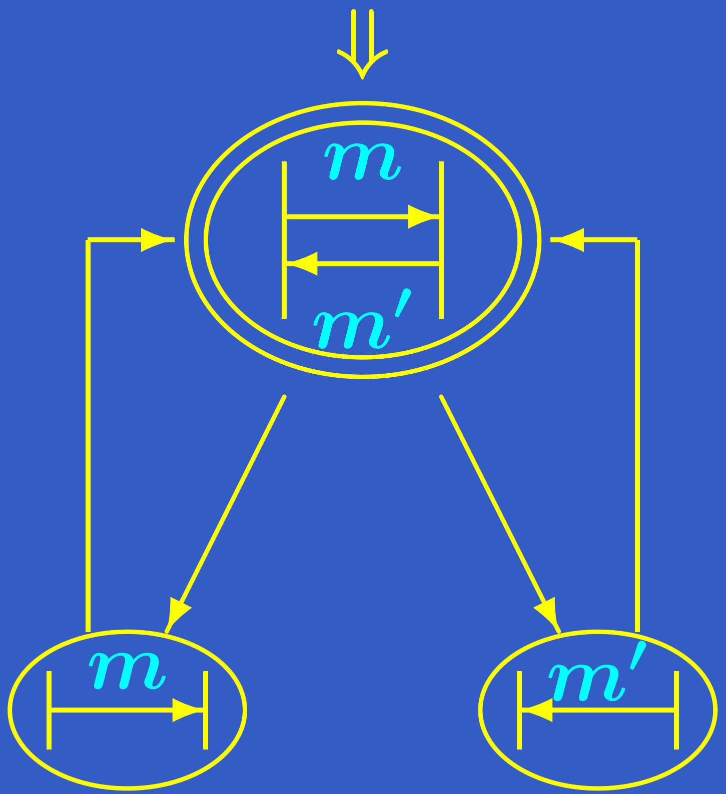

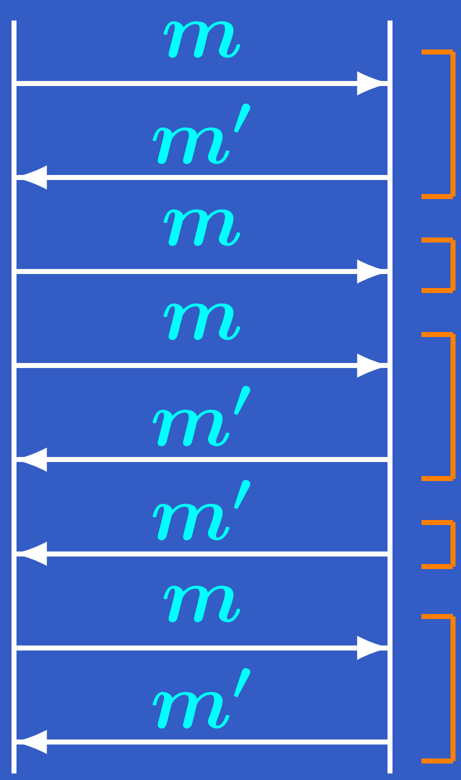

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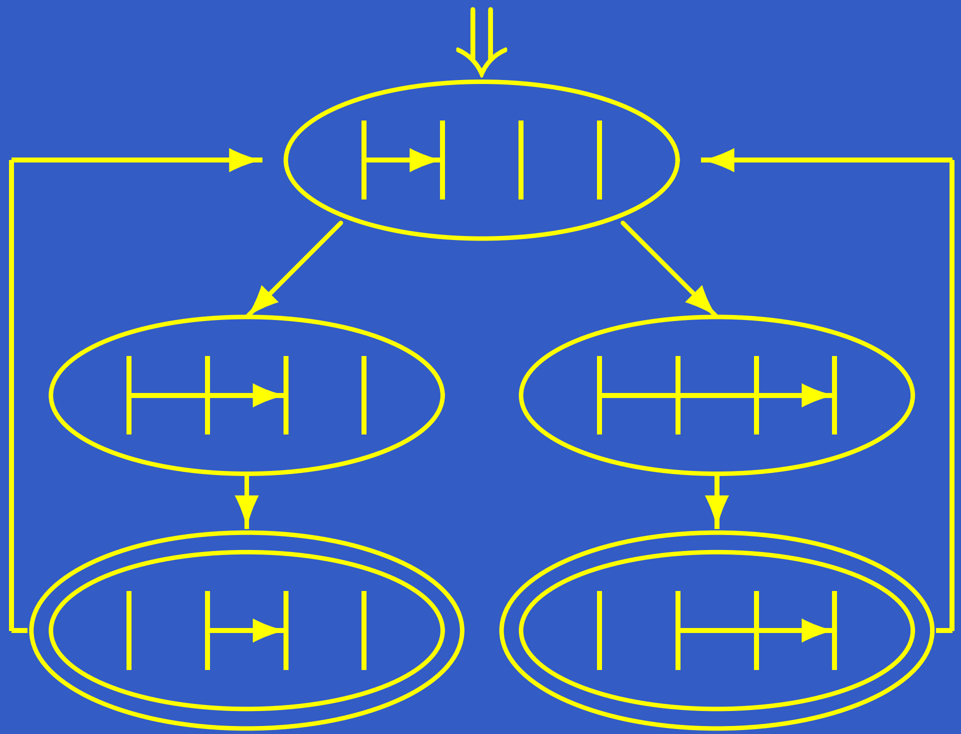

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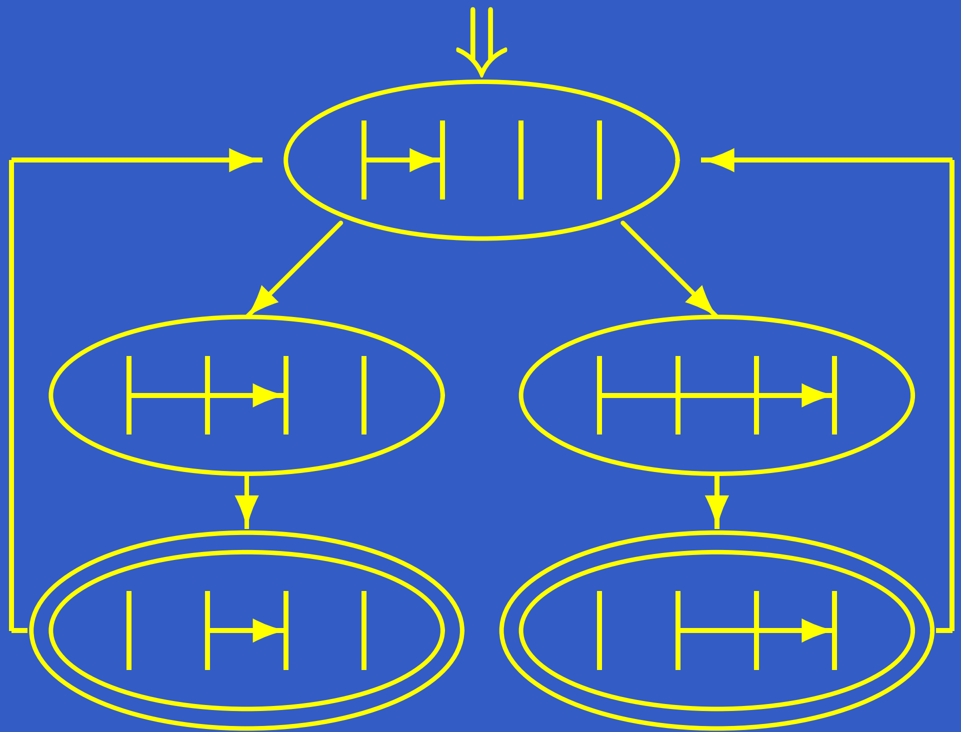

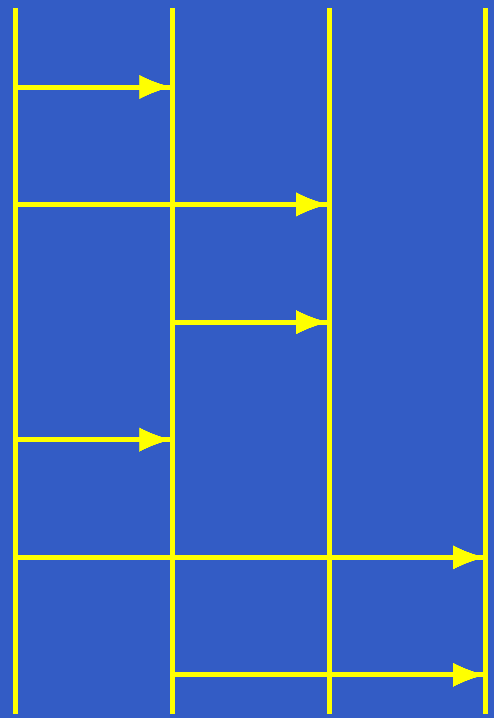

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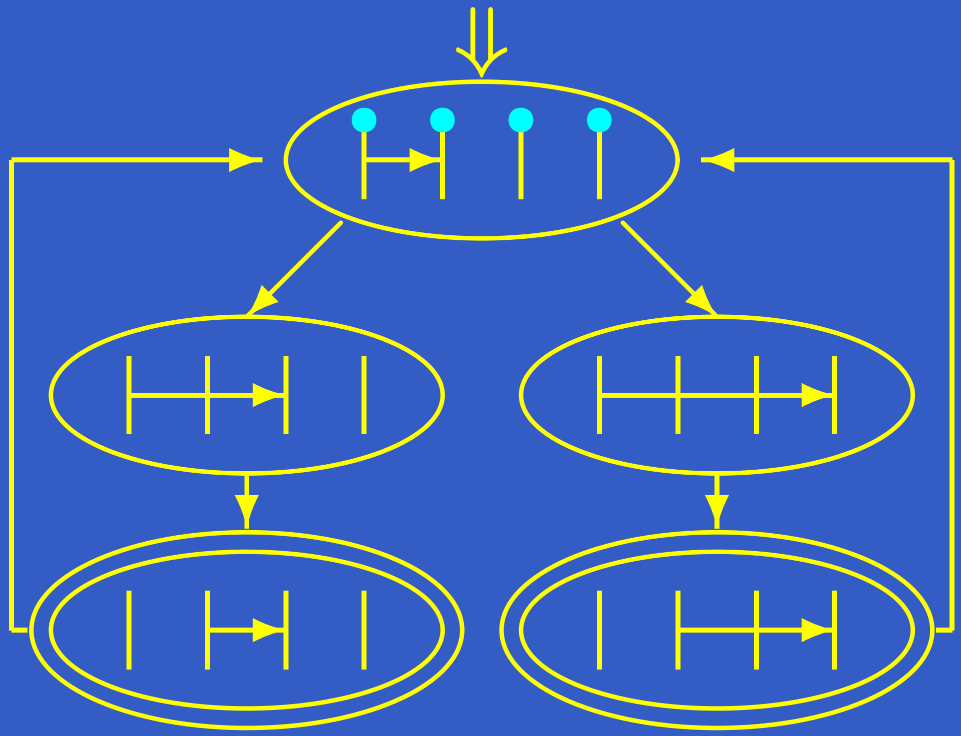

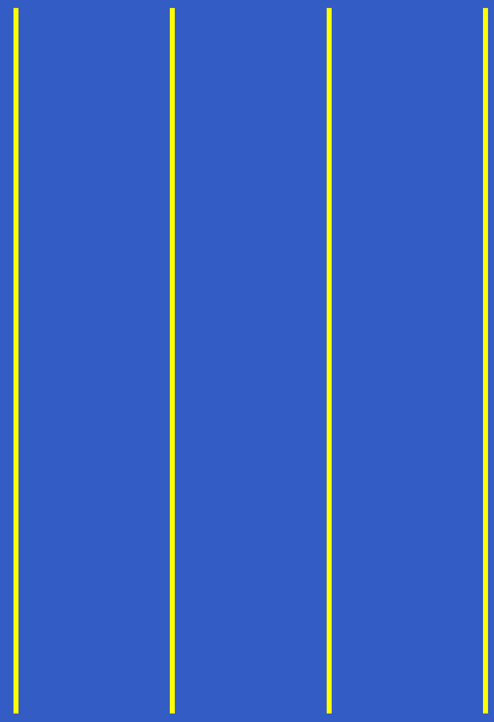

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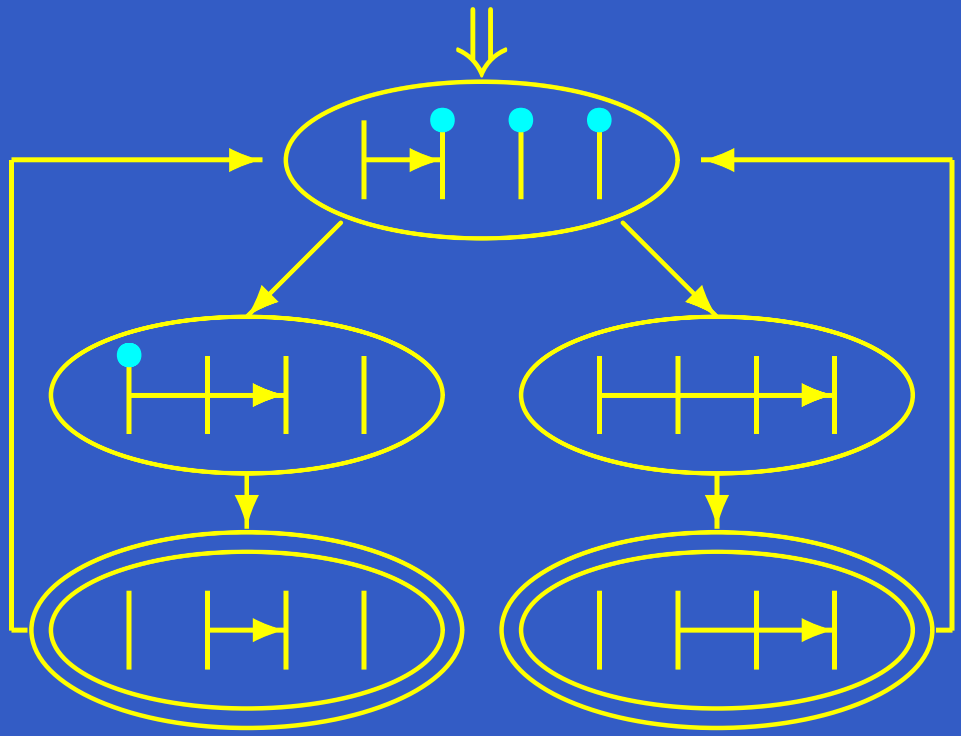

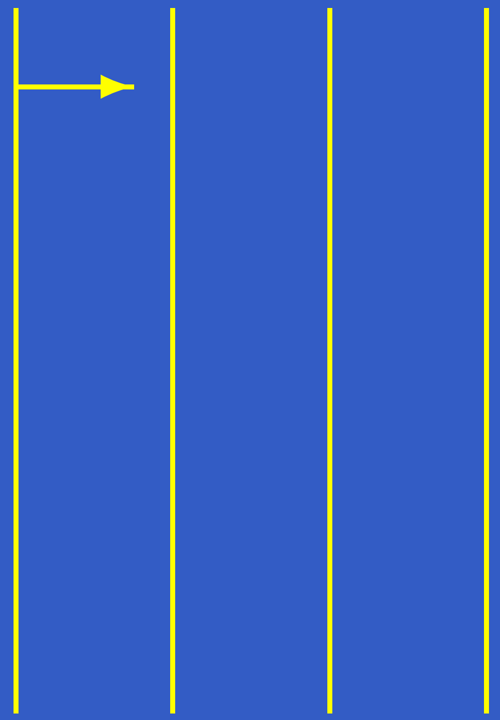

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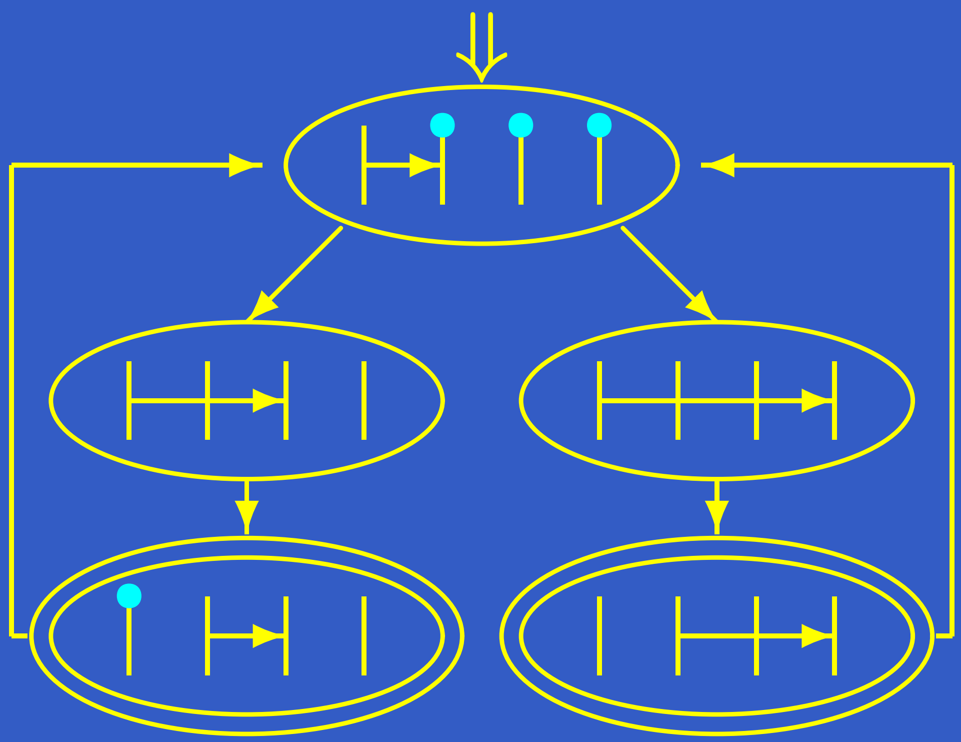

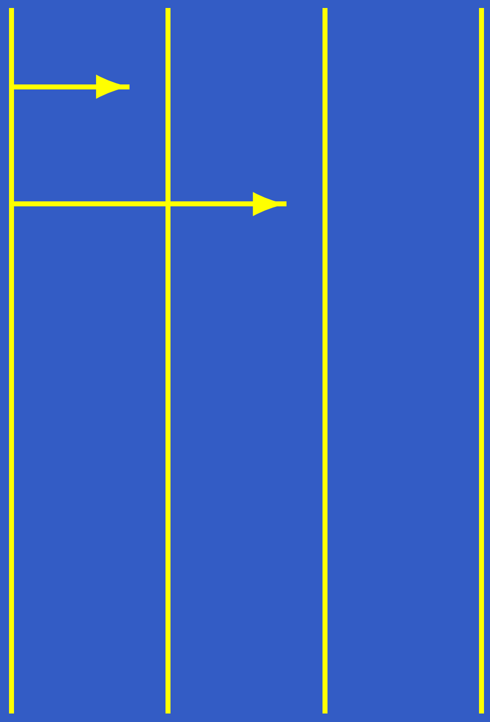

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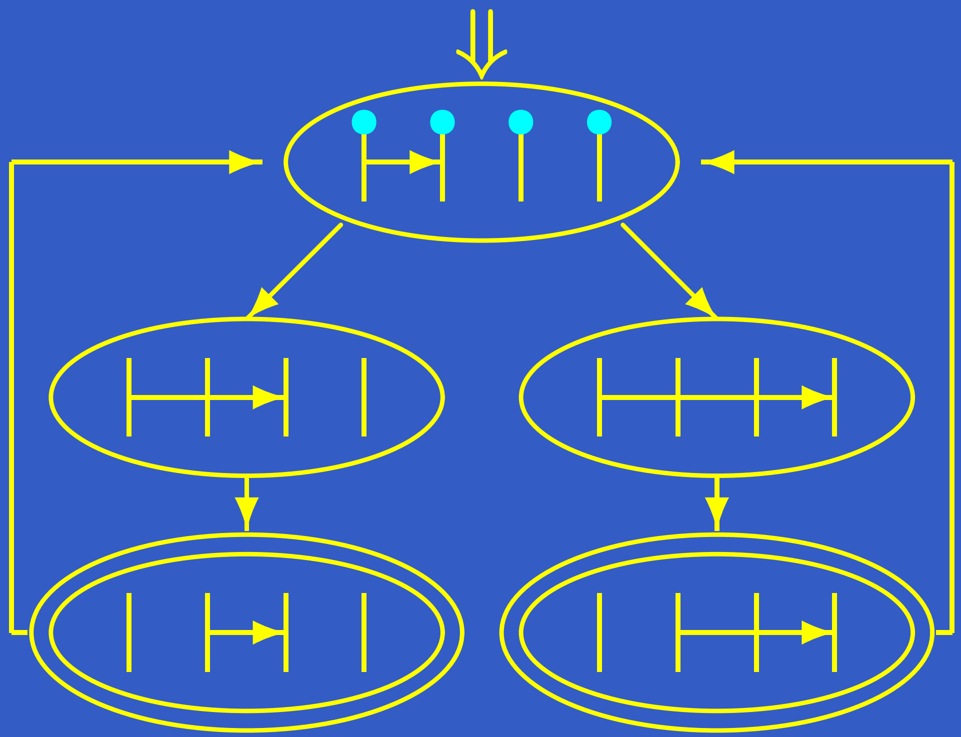

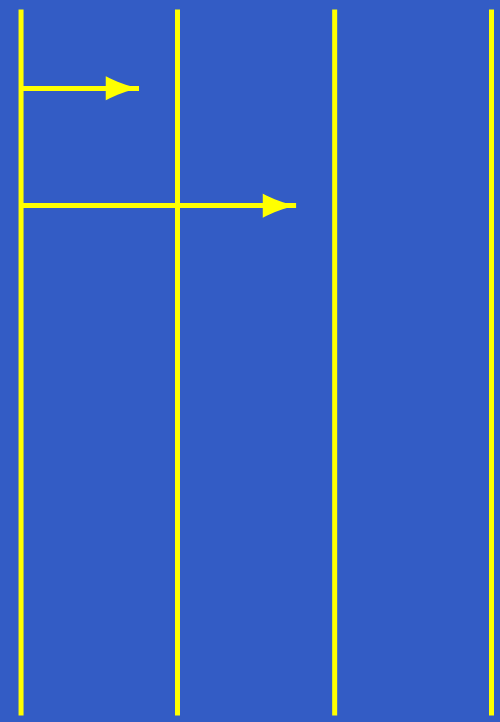

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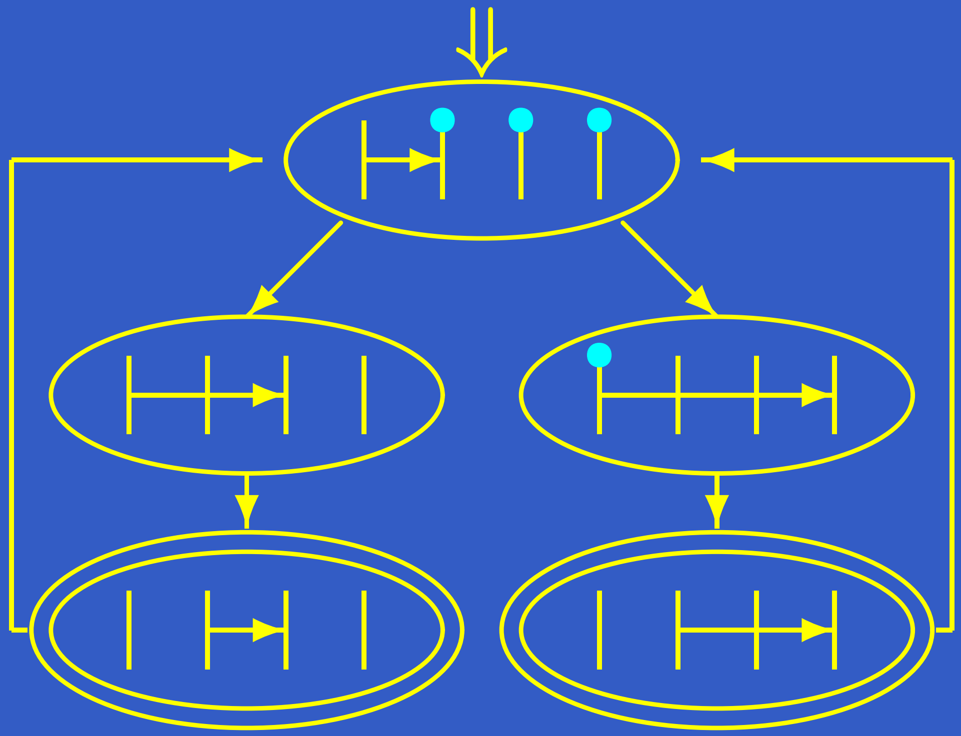

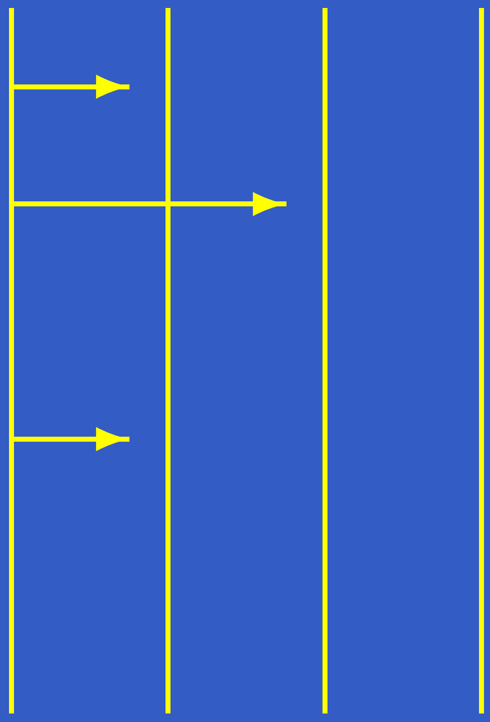

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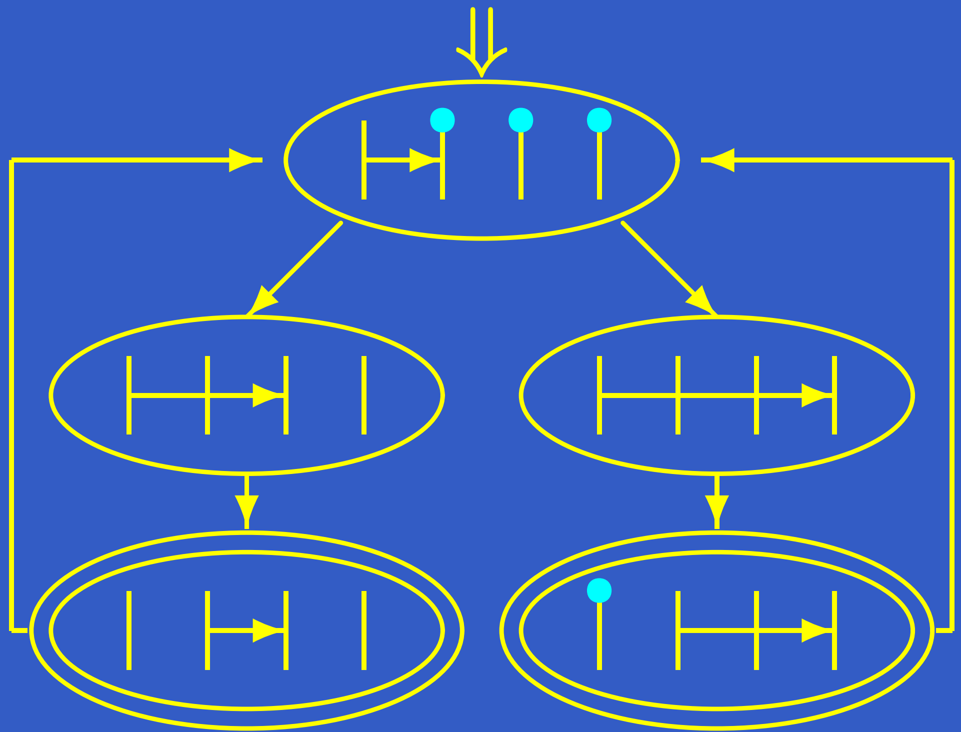

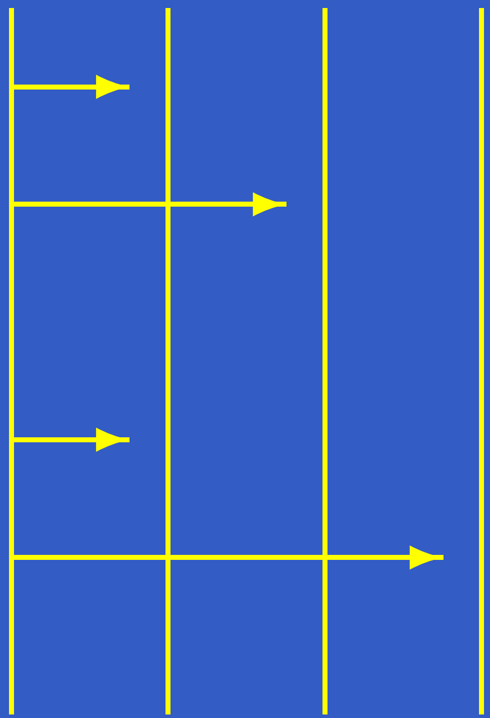

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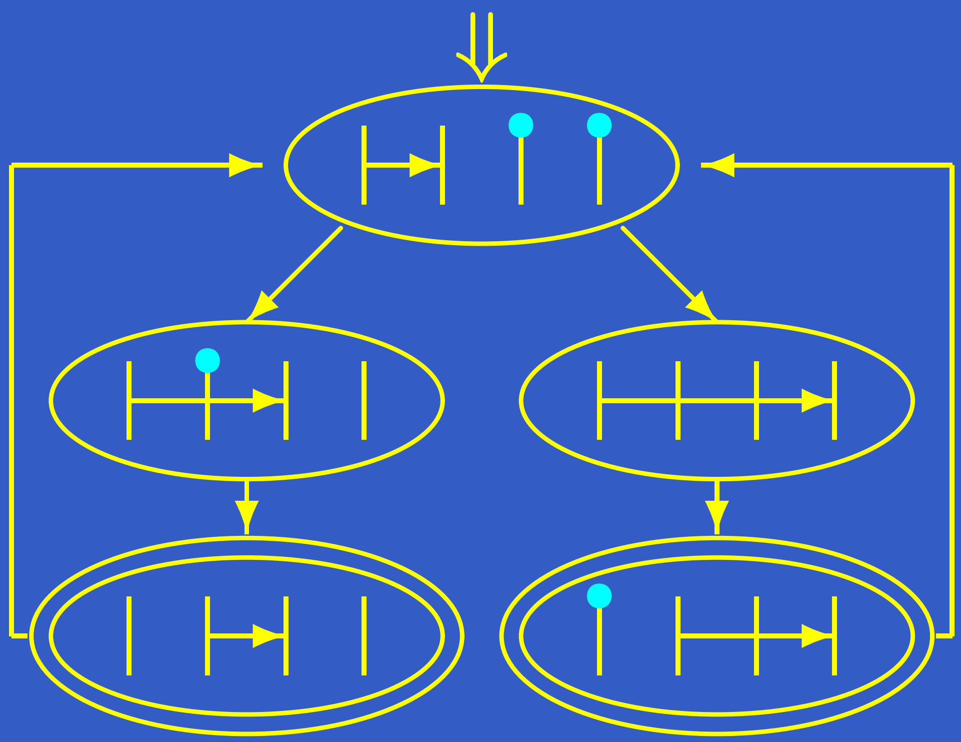

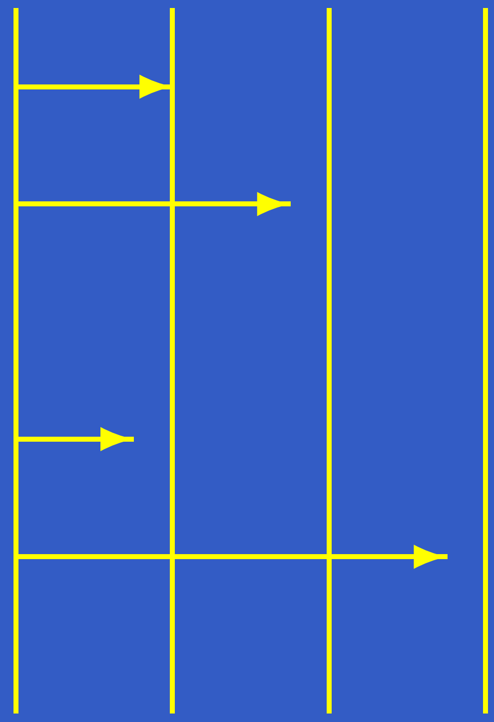

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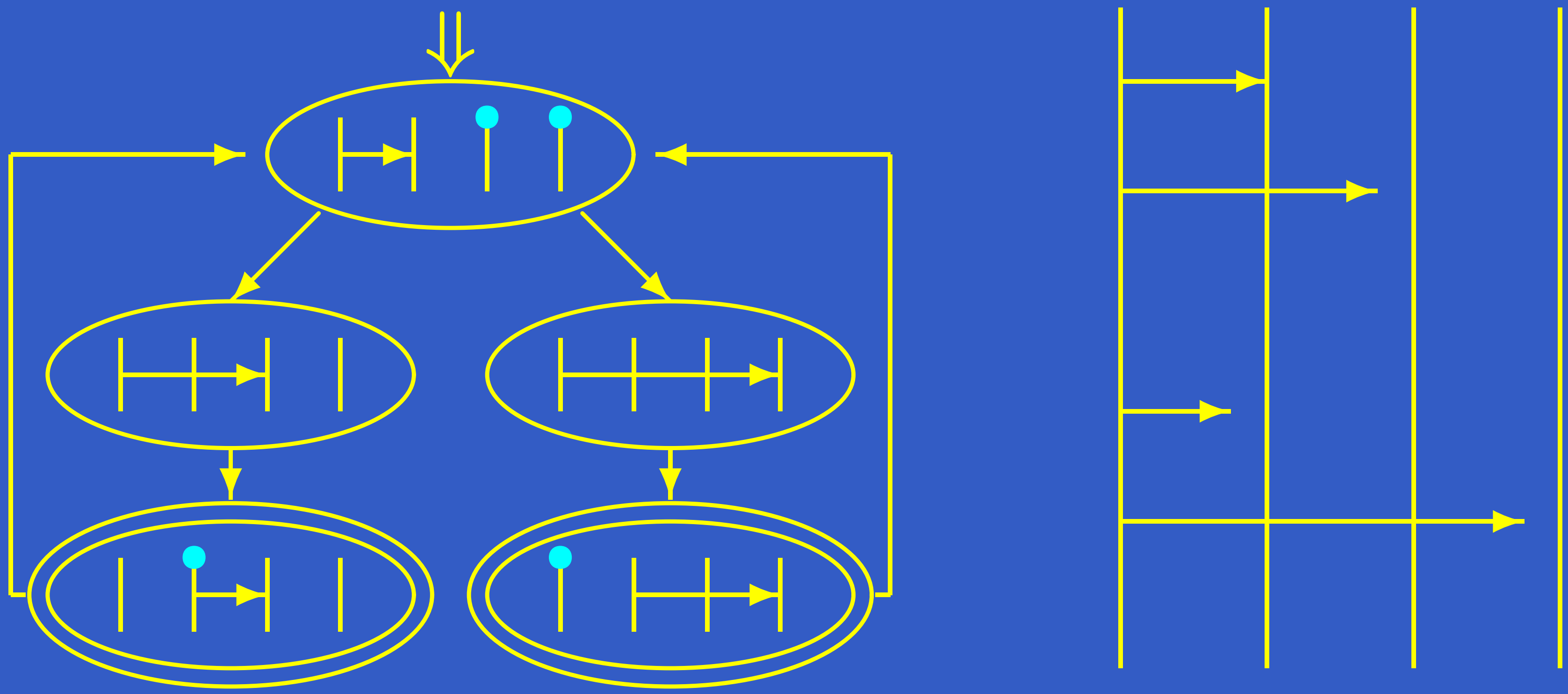

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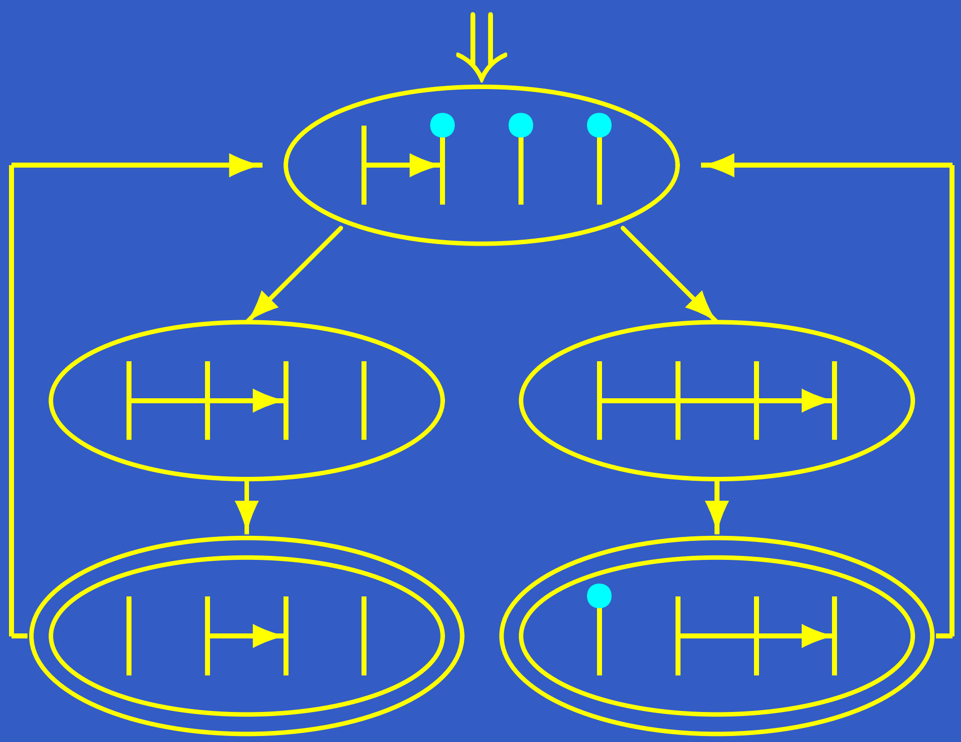

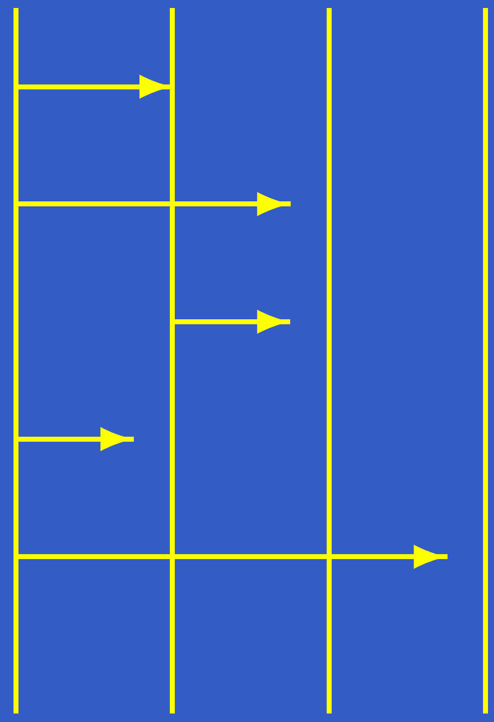

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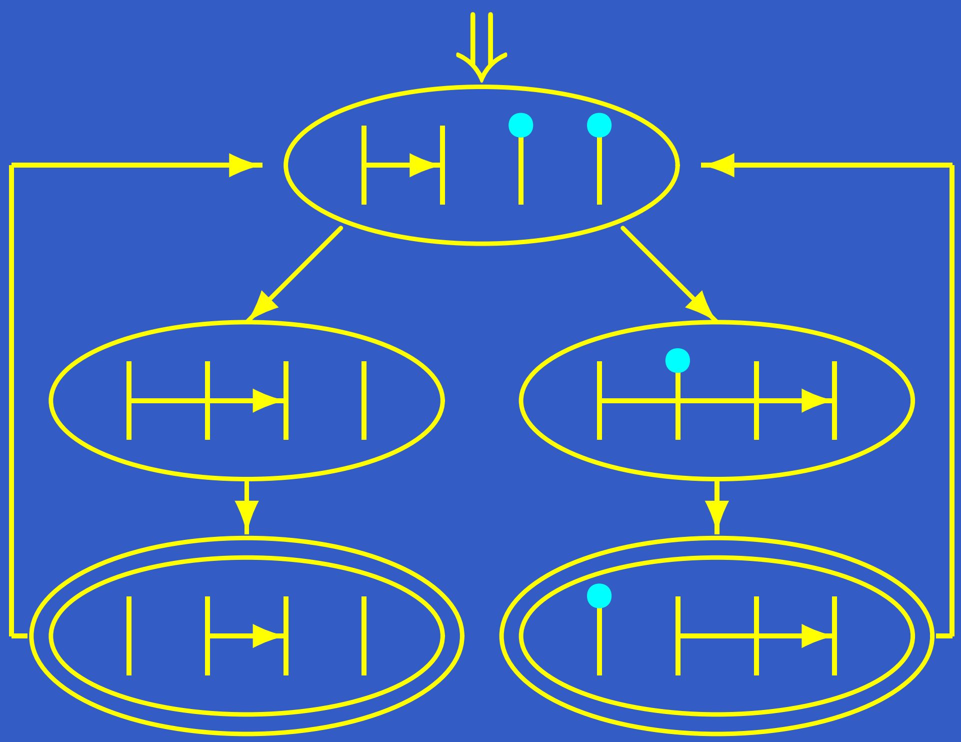

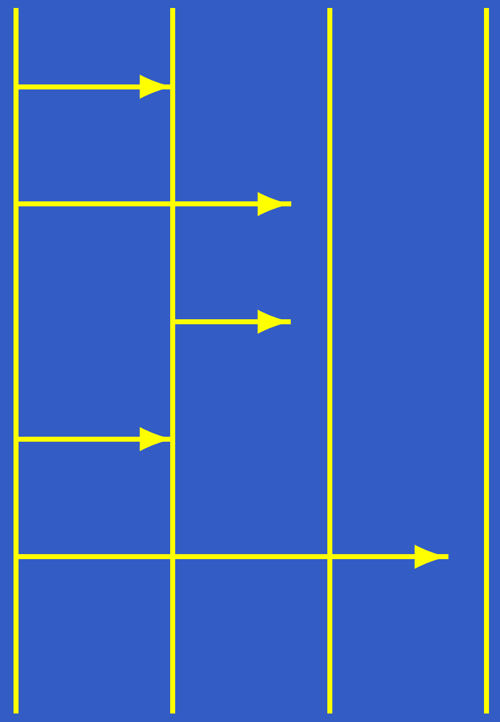

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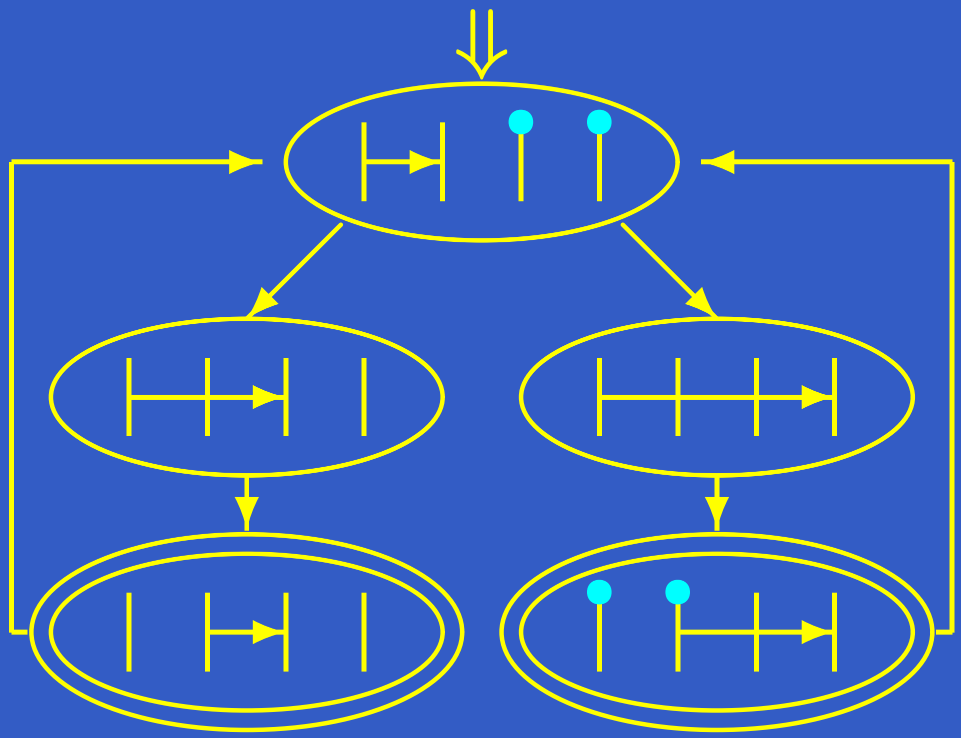

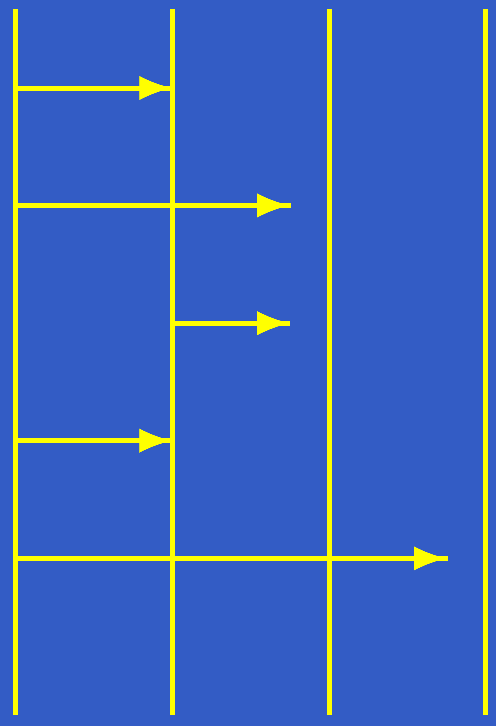

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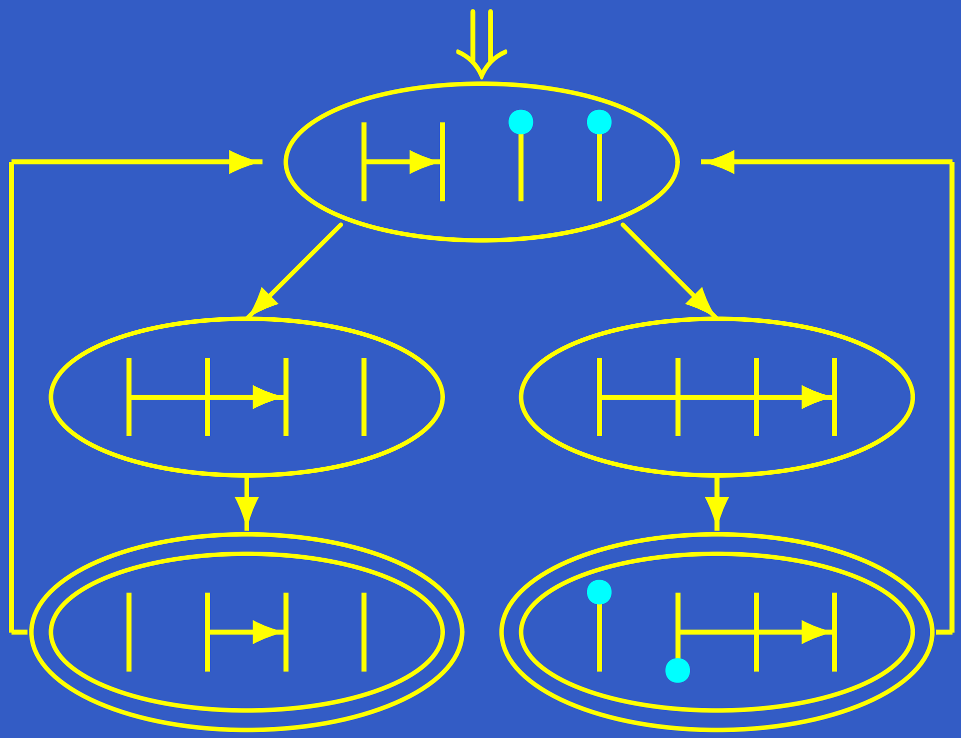

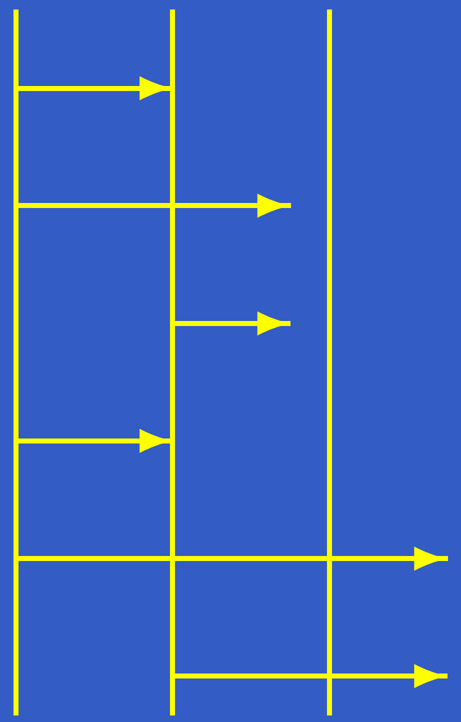

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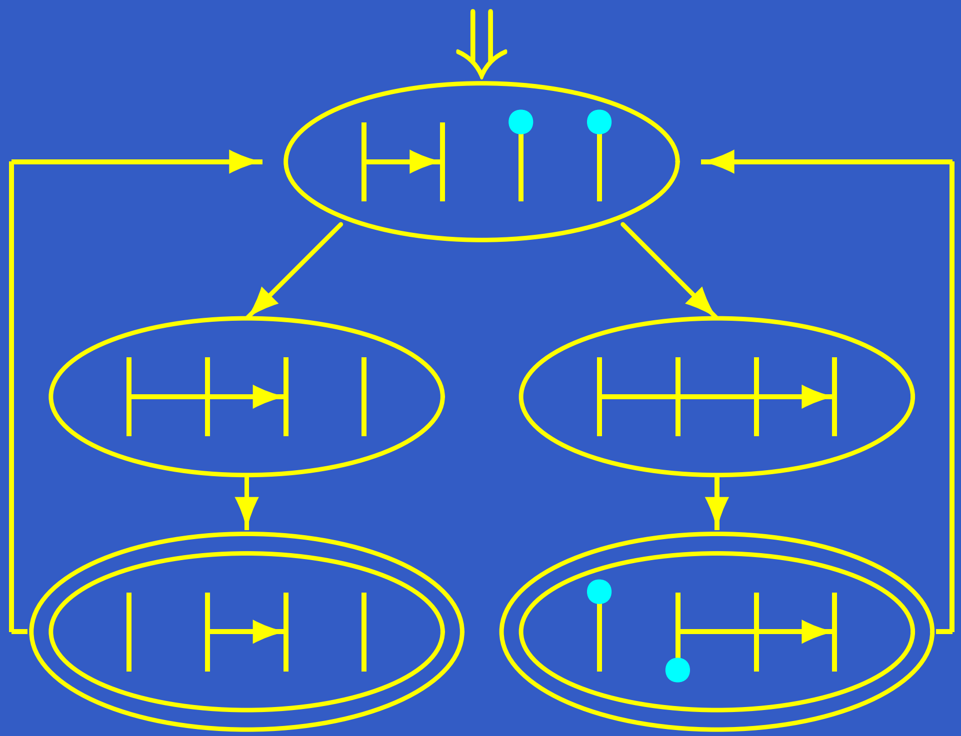
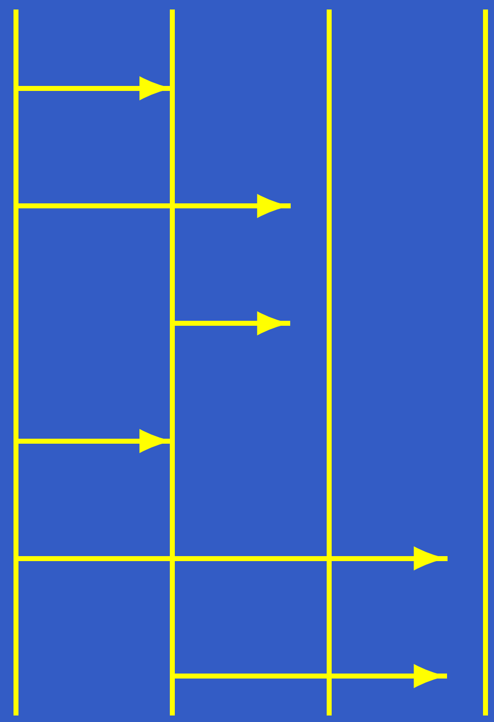
- “Executing” HMSC may require unbounded history





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- Set of scenarios specify both the system and its desired properties
- Checking positive specifications:
  Inclusion of MSC languages
- Checking negative specifications:
  Is the intersection of MSC languages empty

Verification using scenarios . . .

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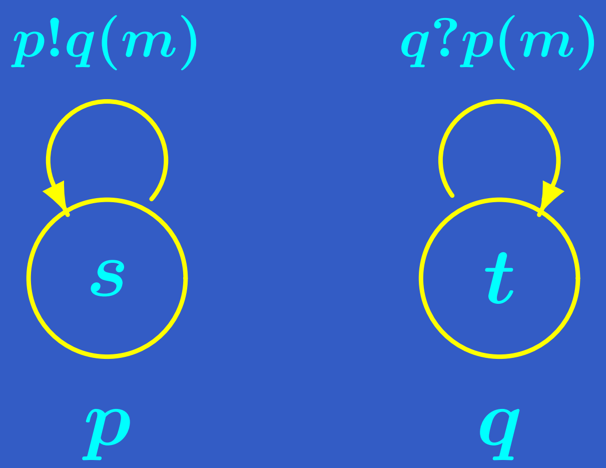

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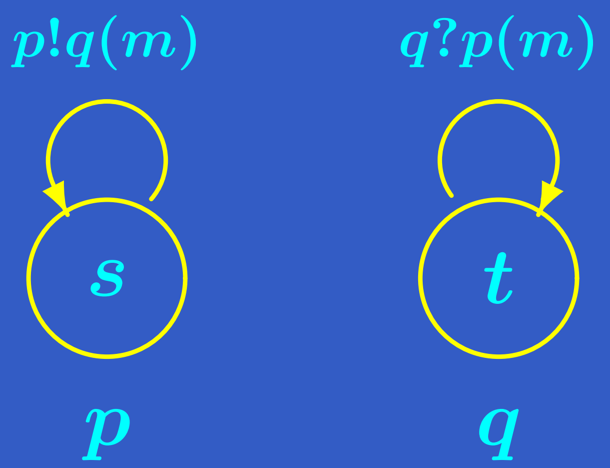

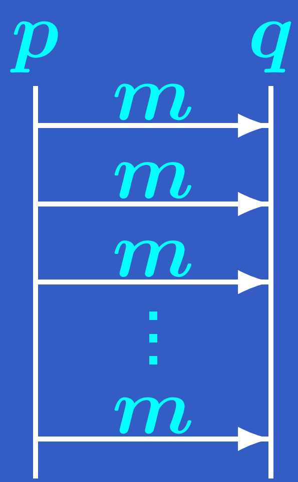

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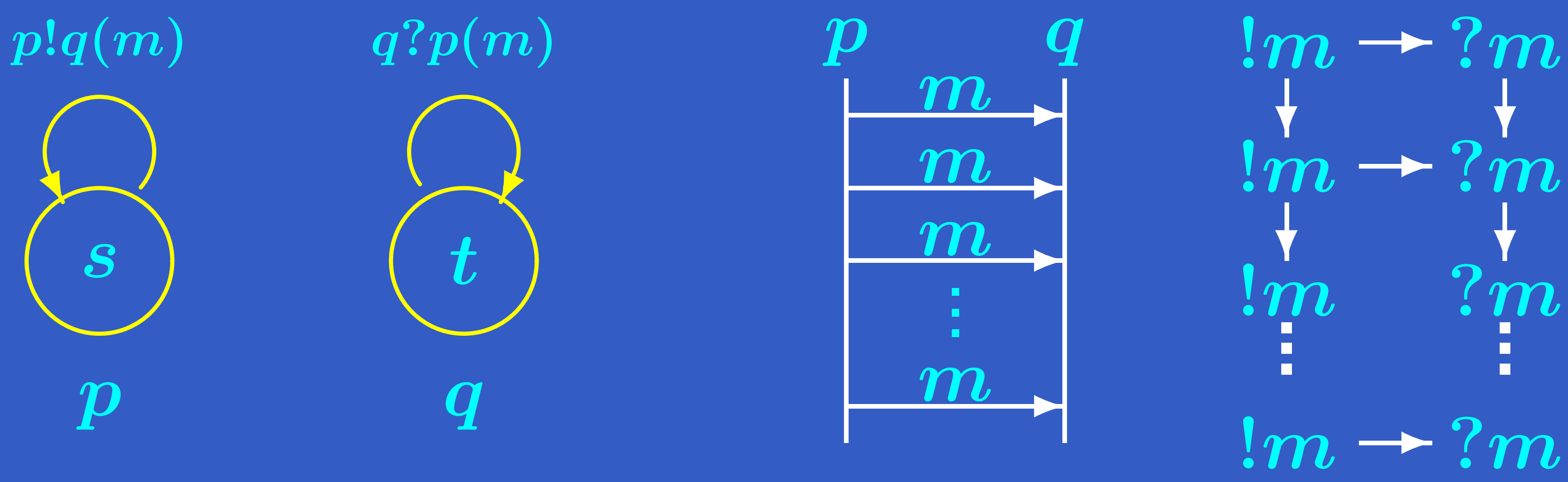

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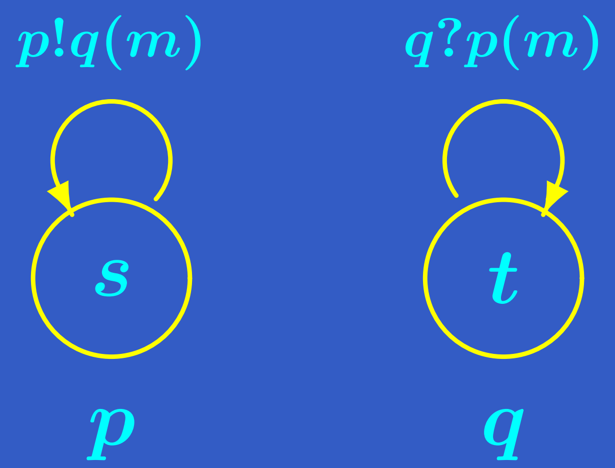

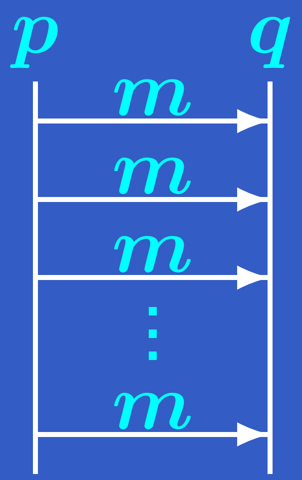

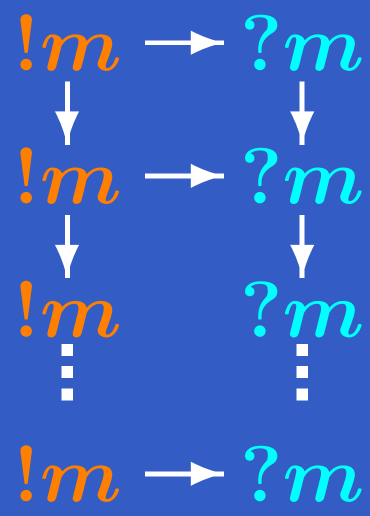

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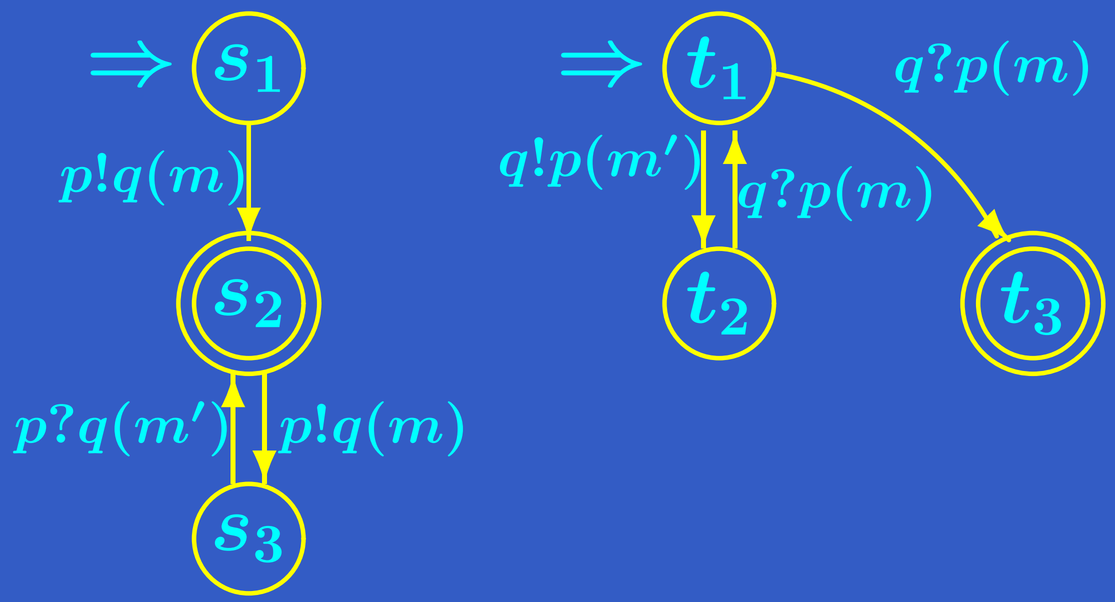

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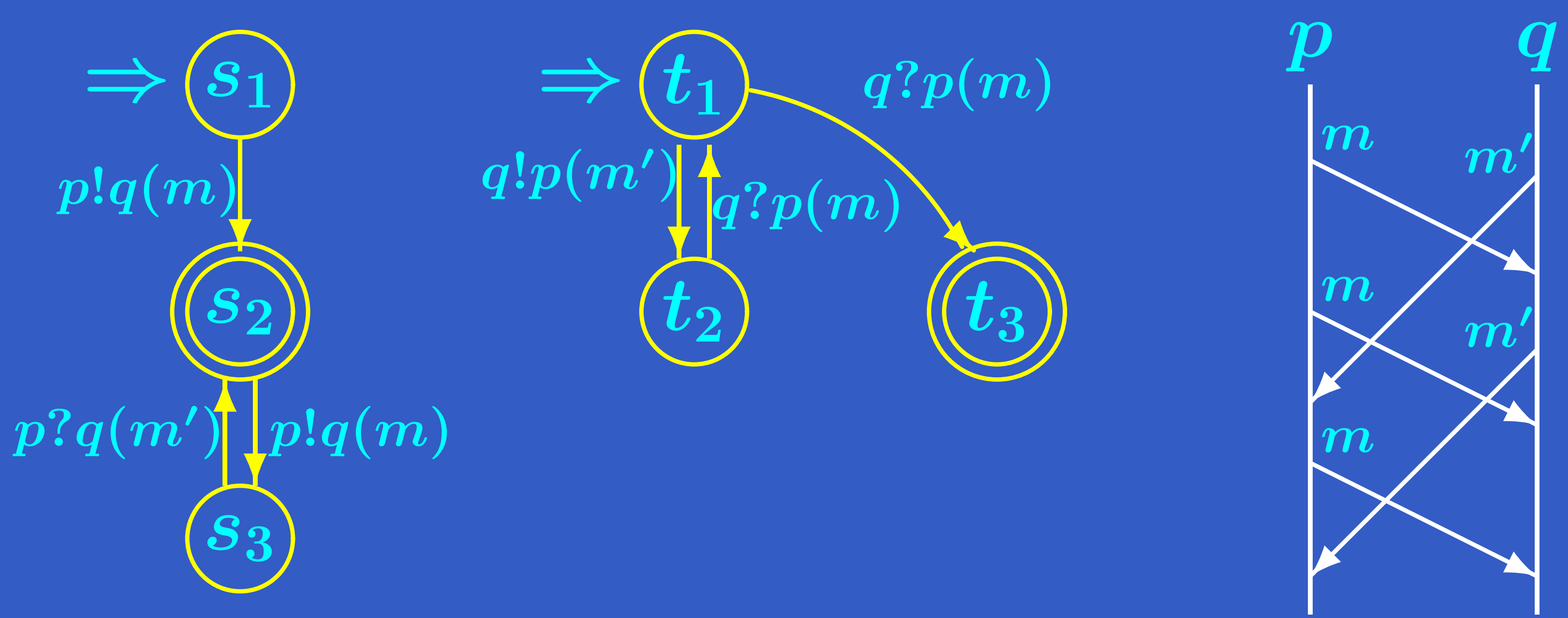

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- Converse is also true [MNS, CONCUR '00]
- Regular MSC languages have a nice theory
  [HMNST, I&C '0?]

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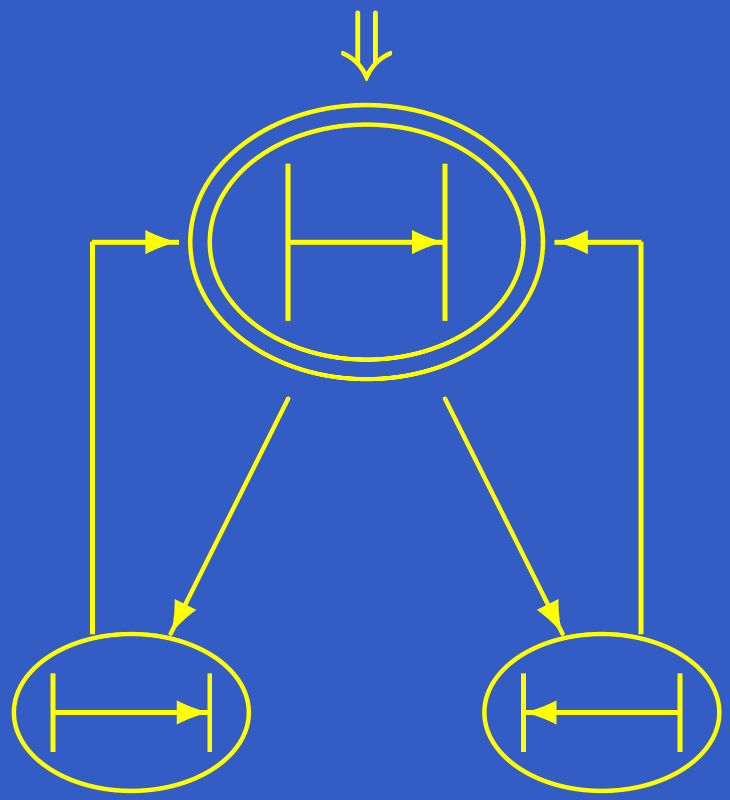

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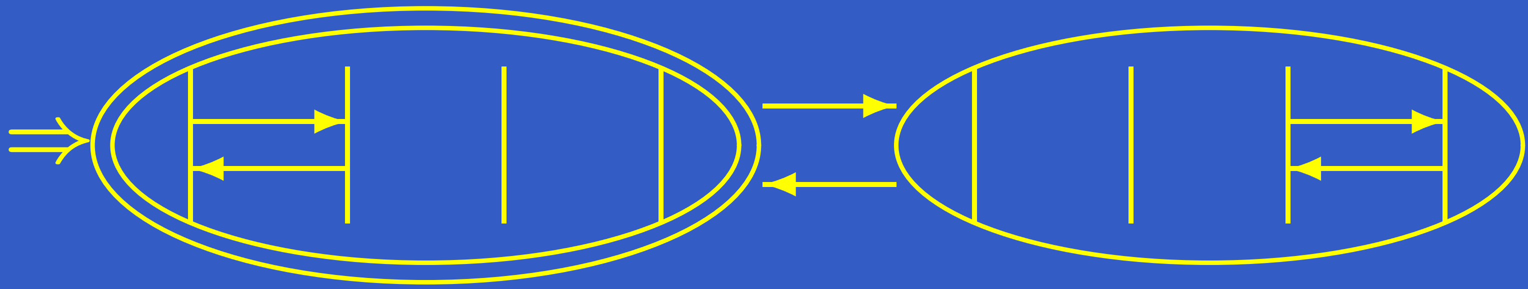

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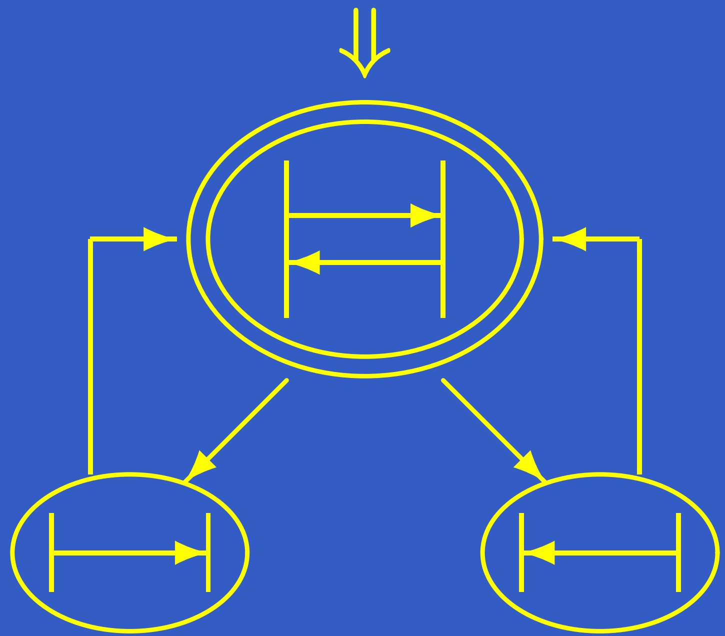

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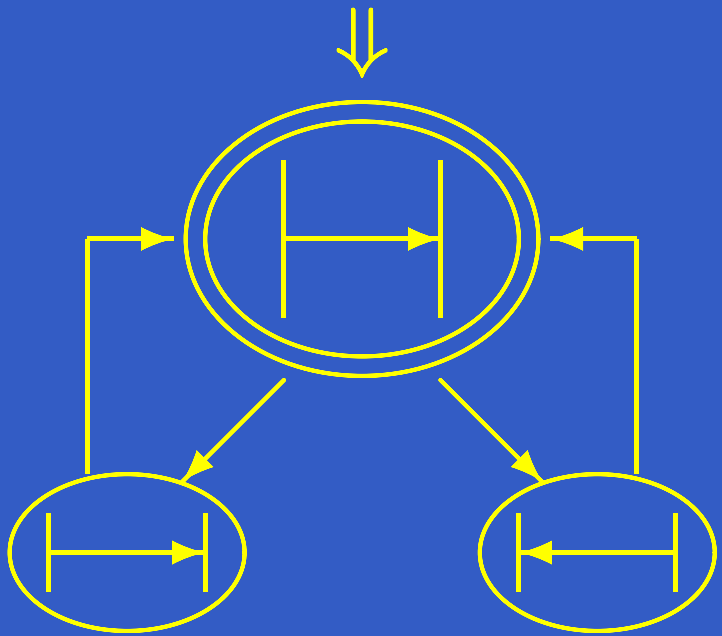

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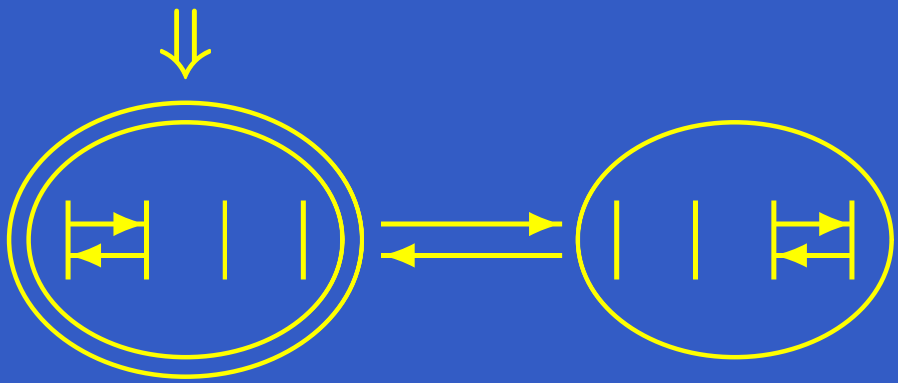

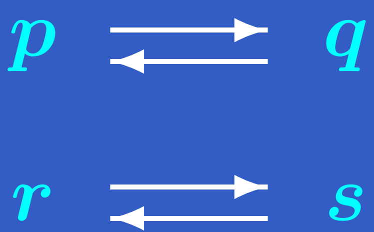

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- Construct a regular set of representative linearizations that cover the MSC language

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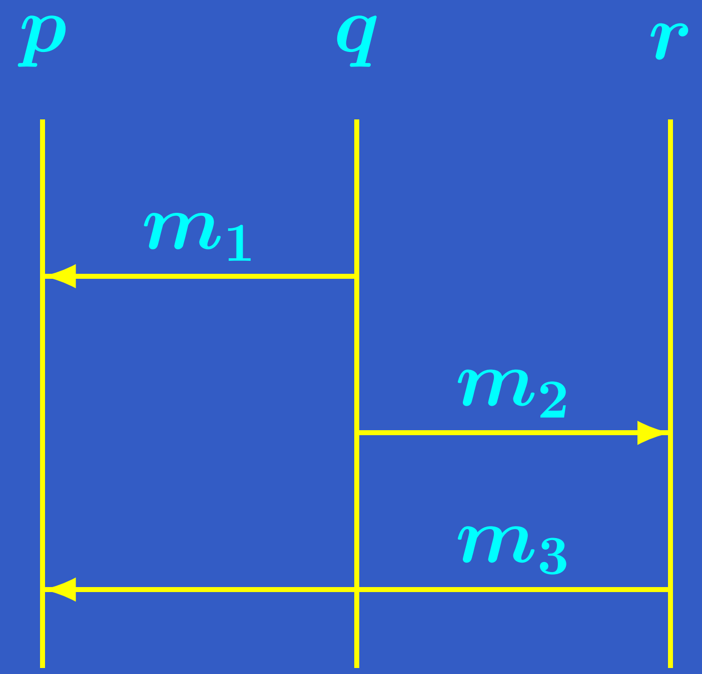

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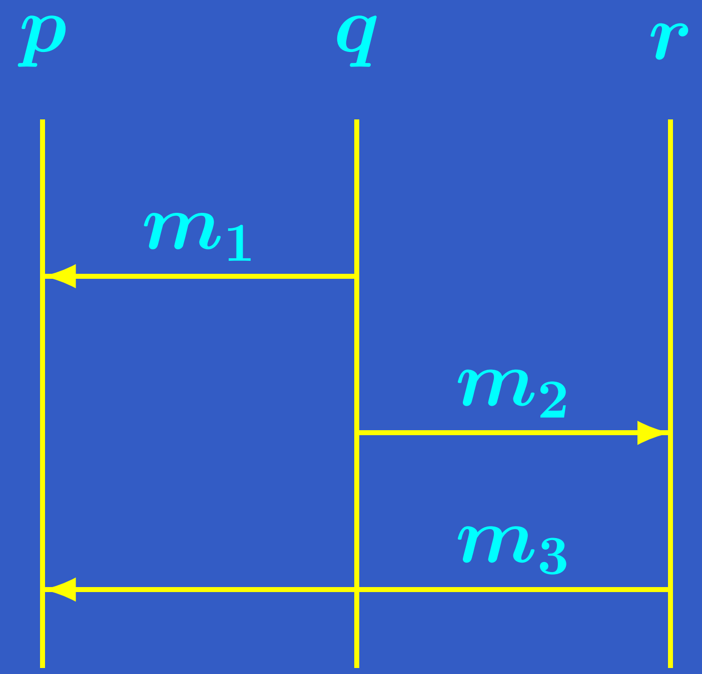

- Is it reasonable to insist that m_1 arrives before m_3?

Race Conditions [AHP, TACAS '96]

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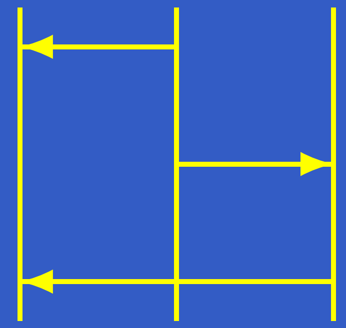

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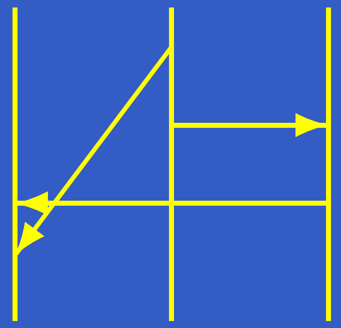

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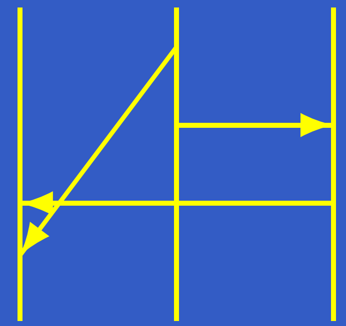

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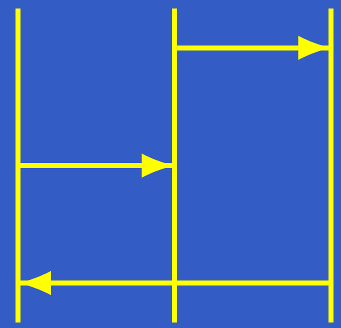

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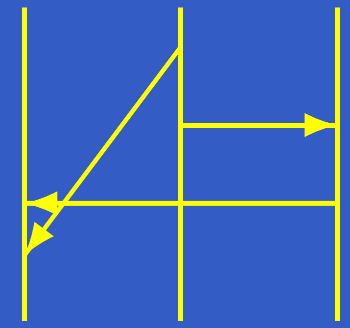

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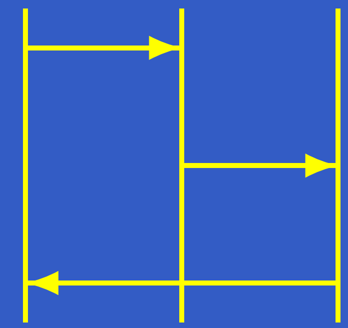

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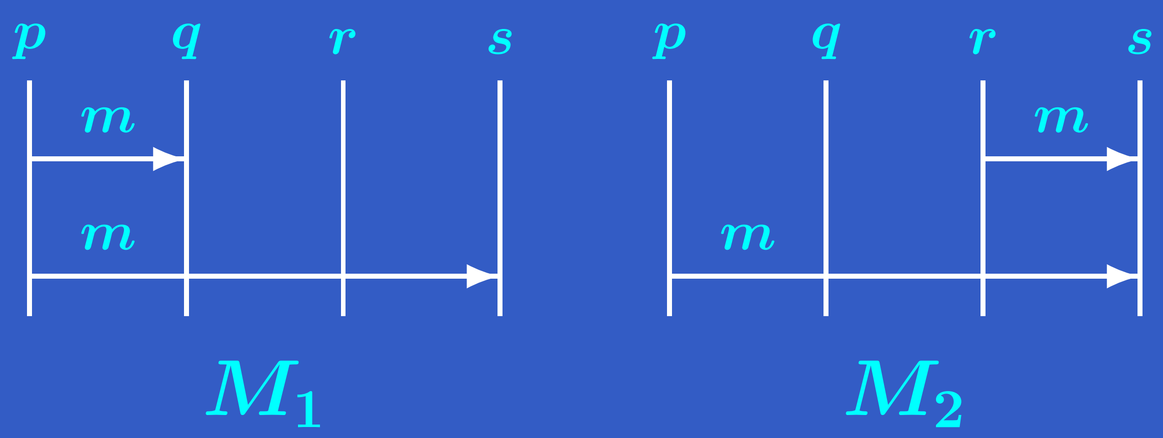
  - Without race condition closure, backtracking appears unavoidable [DM, SPIN '03]

Implied scenarios [AEY, ICSE ’00]



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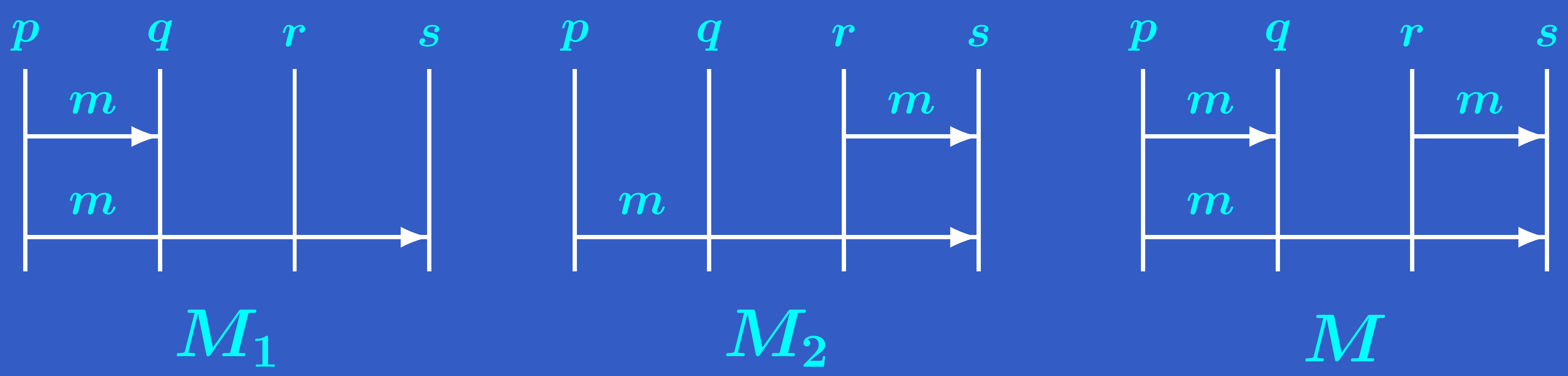

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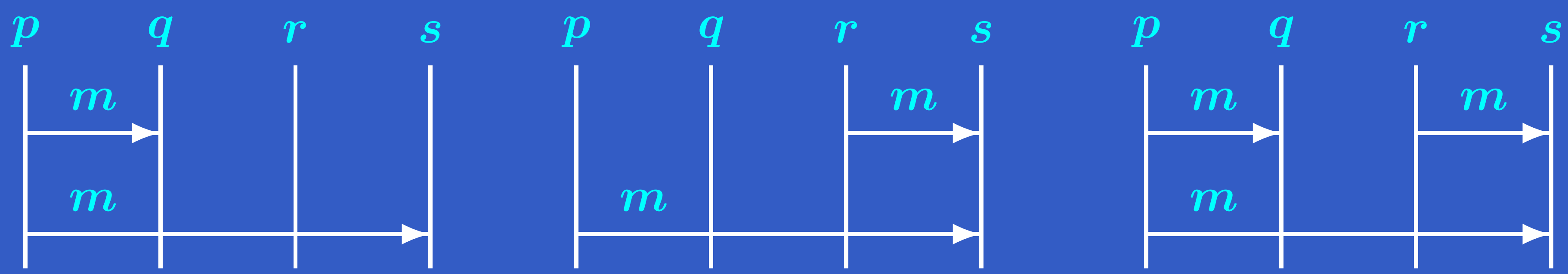

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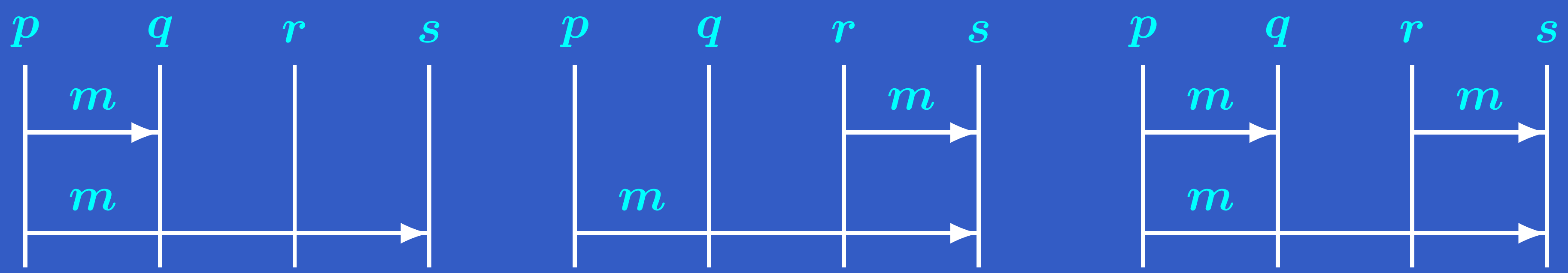

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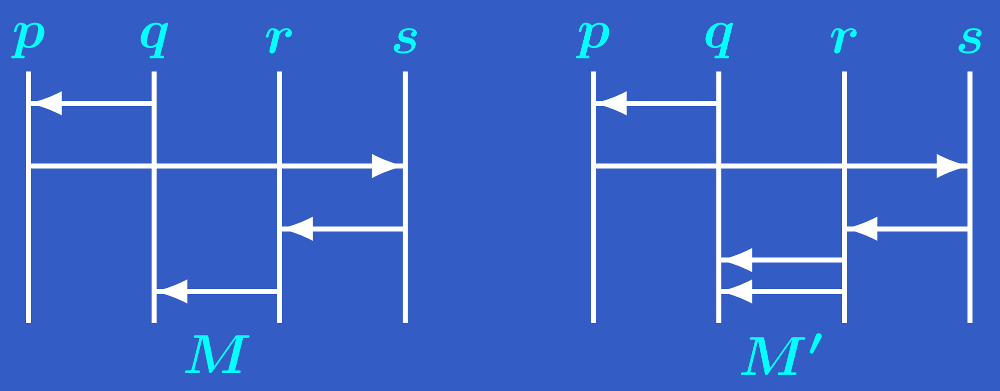

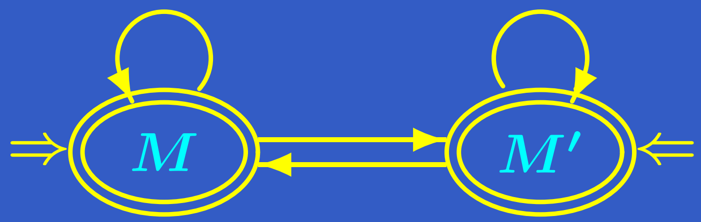

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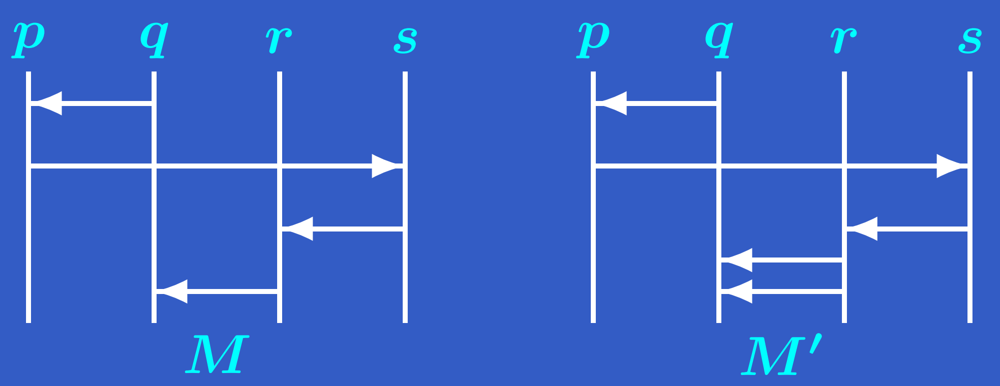

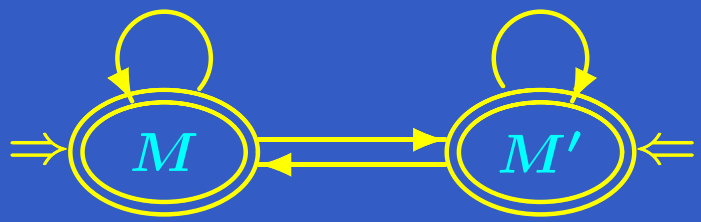

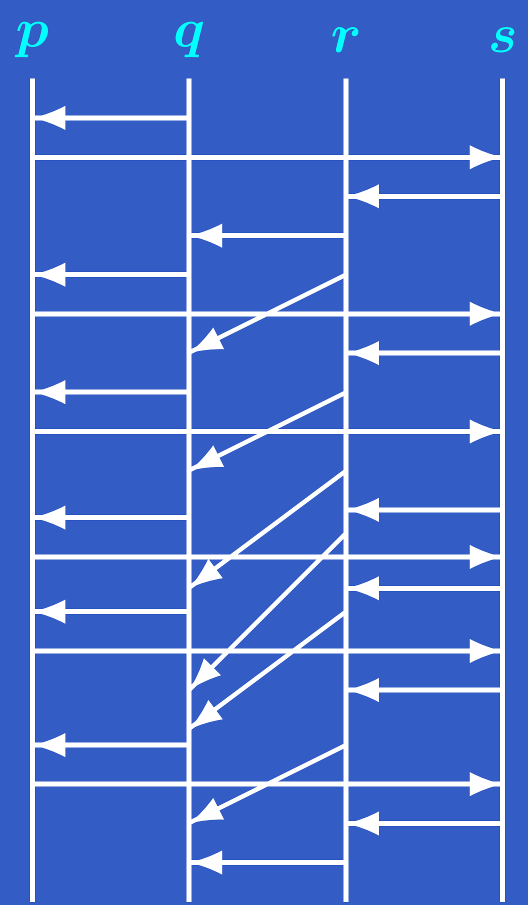

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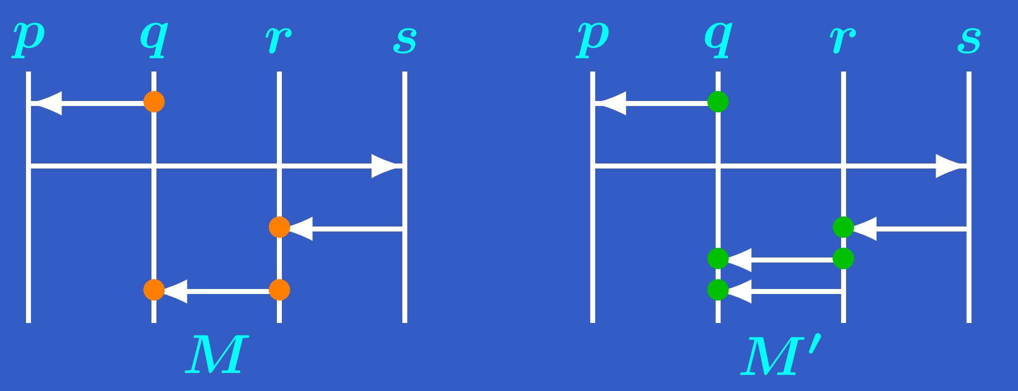

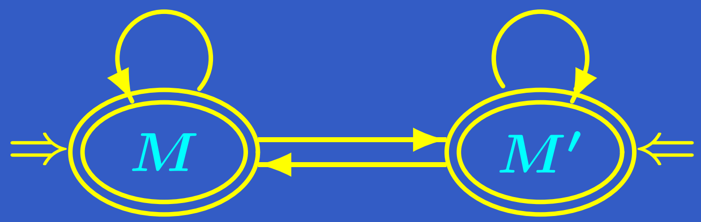

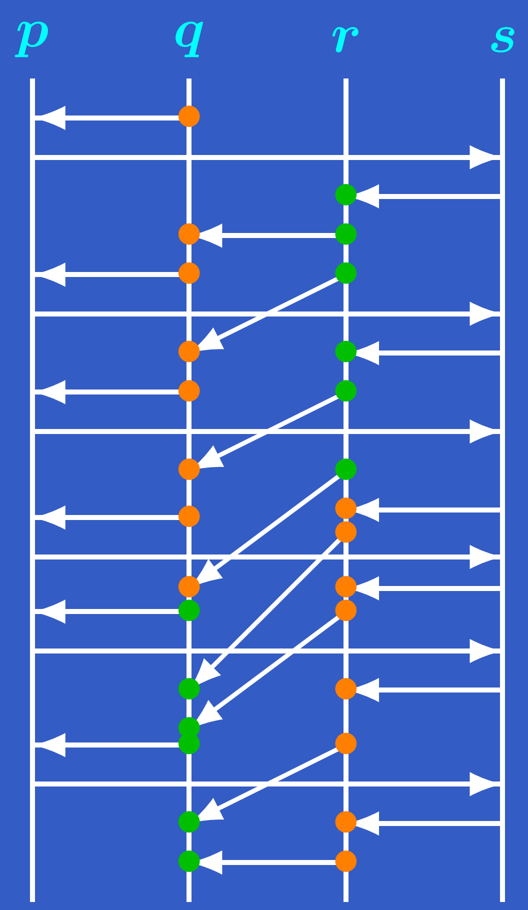

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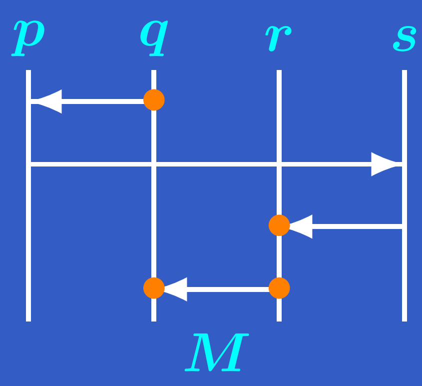

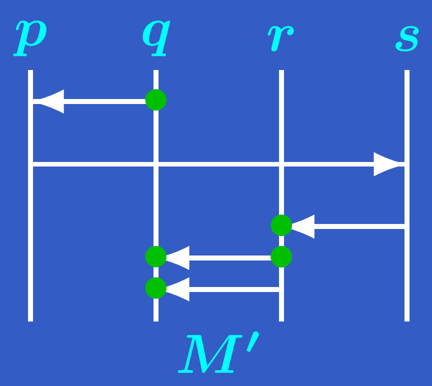

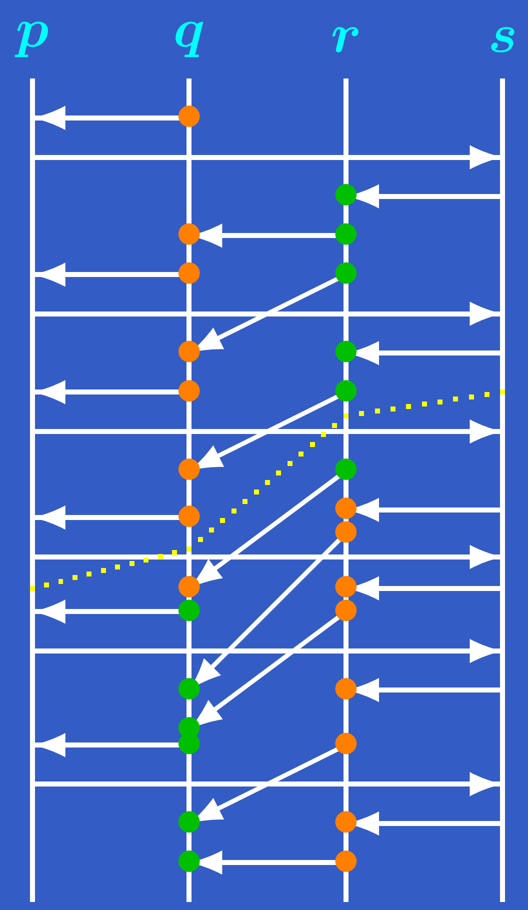

Confusing $M^{2k}M'^{k}$ and $M'^{k}M^{2k}$ generates upto k messages in $p \longrightarrow s$ channel

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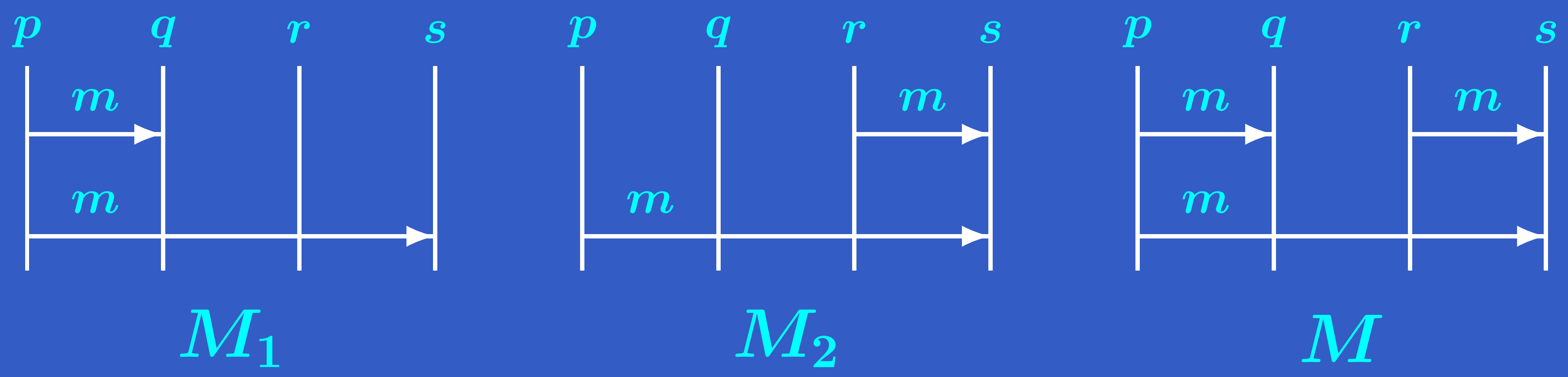

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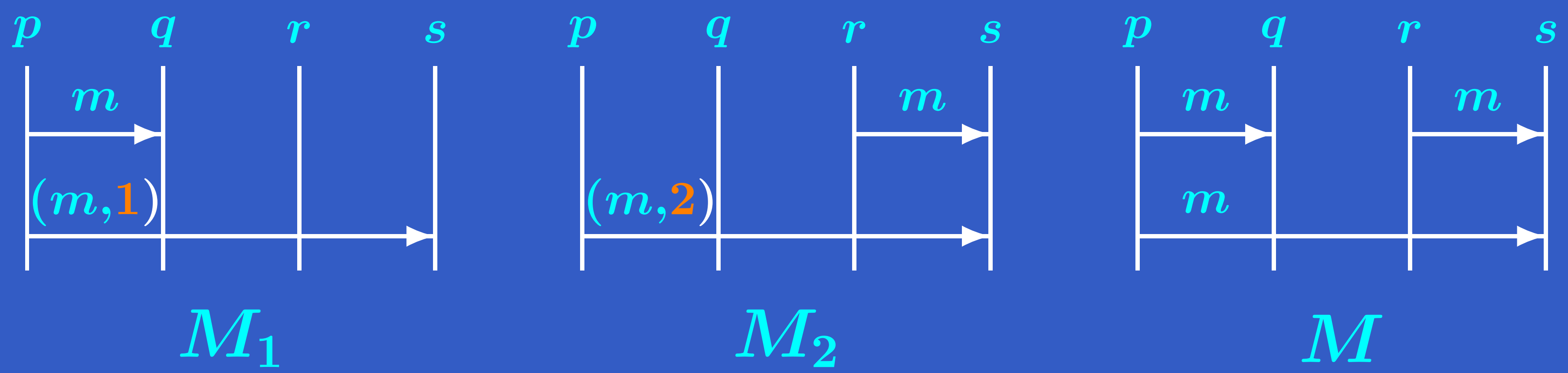

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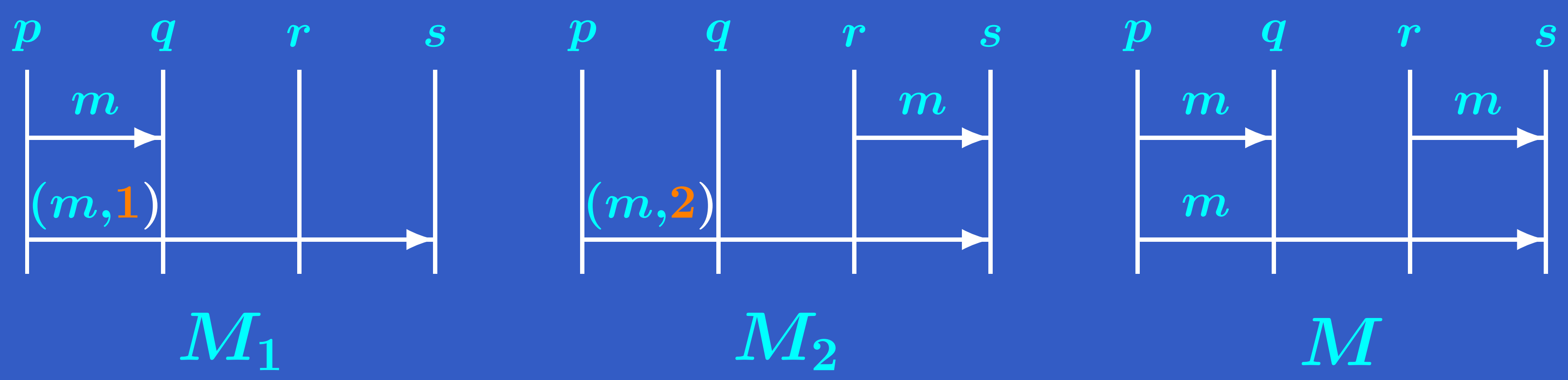

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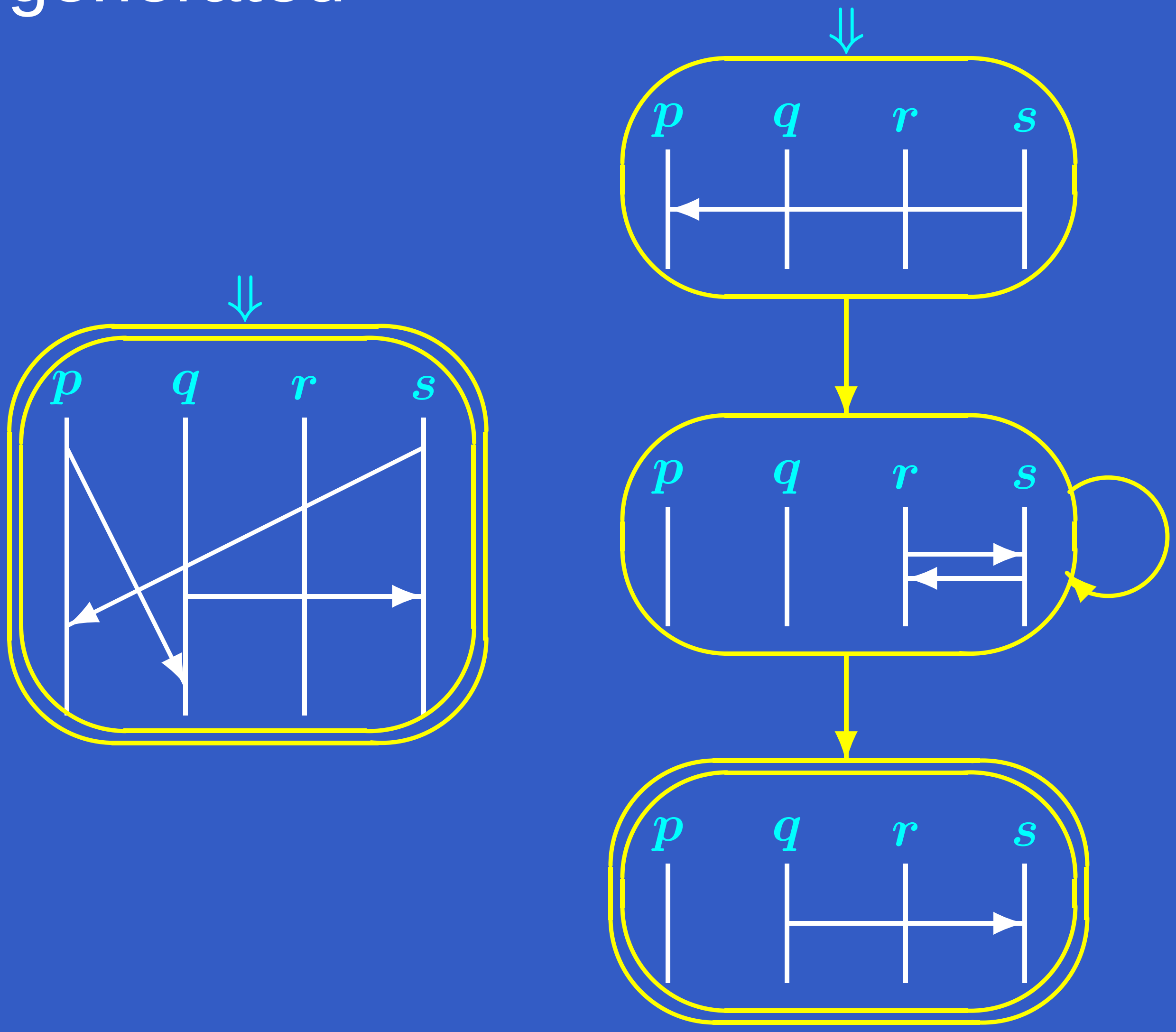

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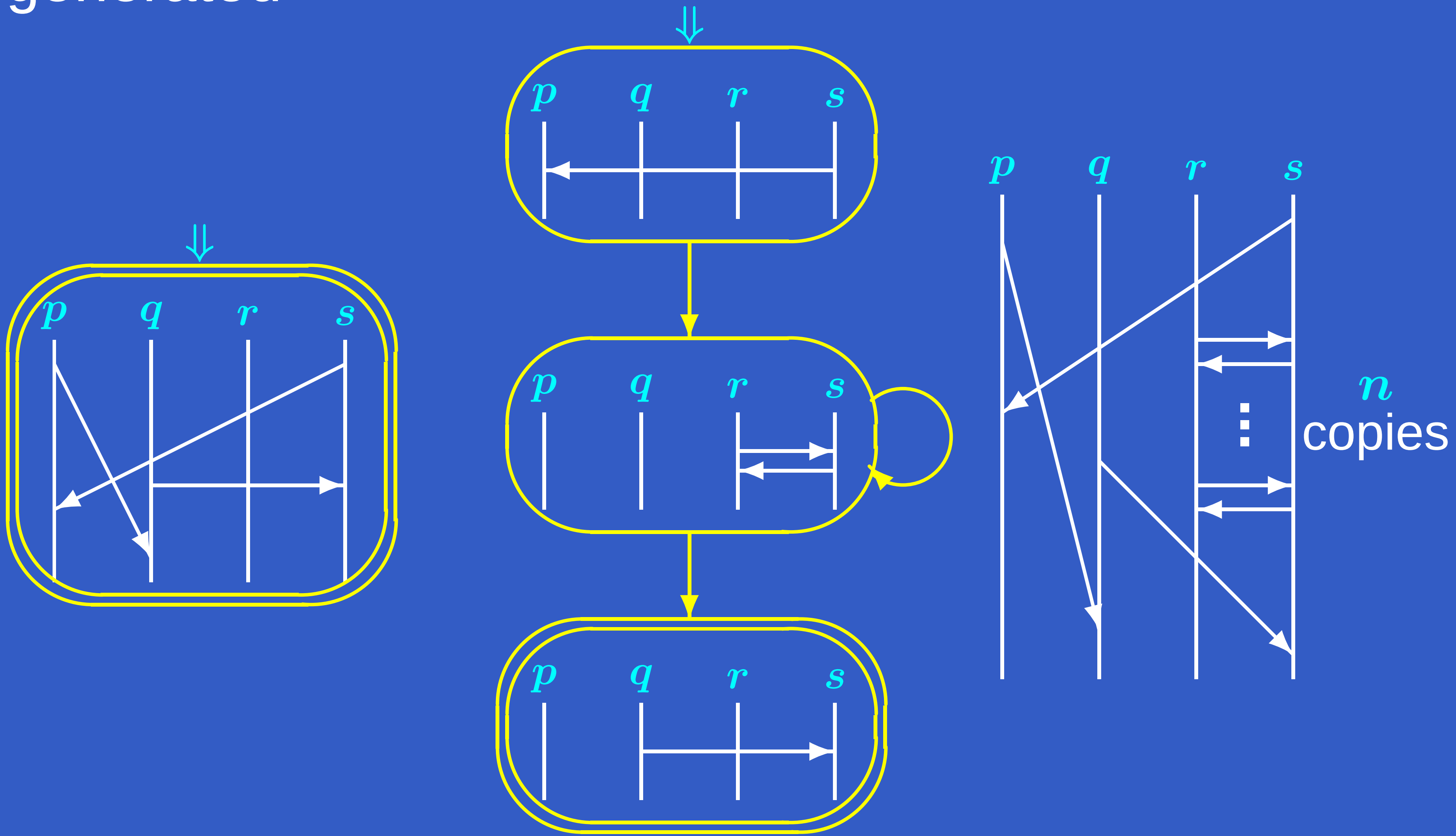

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- Semantics of MSCs is not completely straightforward
  - Race conditions
  - Implied scenarios

Summary

- Scenario based specifications are intuitively easy to use
- Verification requires computing $L_{pos} \subseteq L_{sys}$ and $L_{neg} \cap L_{sys} \neq \emptyset$
  - Can be solved for regular MSC languages
  - Extended to existentially bounded MSC languages
- Semantics of MSCs is not completely straightforward
  - Race conditions
  - Implied scenarios
- To what extent can verification be done with enriched semantics for MSCs?

Related approaches

Related approaches not covered in this talk

- *Live sequence charts* by Harel et al
- Verification of *Lamport diagrams* by Meenakshi and Ramanujam

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