CS 735: Formal Models for Concurrent and Asynchronous Systems

– Introduction

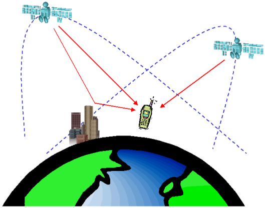
Instructor : Akshay S

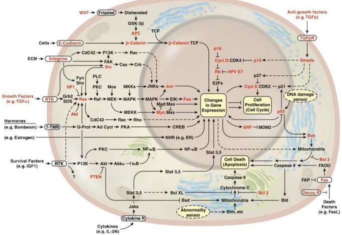
Jan 5, 2018

Course hours: Slot14,
Tuesdays and Fridays 5:30-7:00pm

Goal

Formal Models for distributed and infinite-state systems





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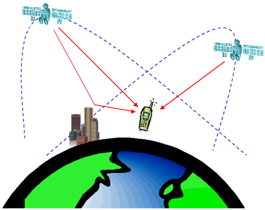
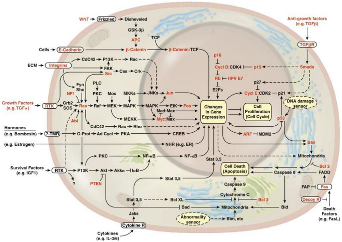
- Distributed: Concurrent, asynchronous, communicating,...





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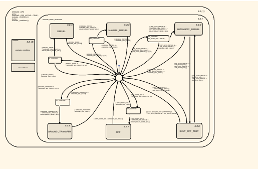
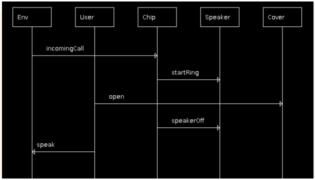
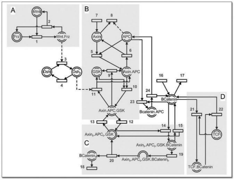
Formal Models for distributed and infinite-state systems

- Distributed: Concurrent, asynchronous, communicating,...
- Formal models: Mathematical description, graphical notations, Automata models







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Questions that we will tackle

- Analysis of such models
- Characterization, relations
- Underlying properties, generalizations

Course contents

Topics and models that we will cover in this course:

1. Petri nets
2. Well-structured transition systems
3. Distributed automata models and their behaviors
4. Extensions and recent advances

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   - Asynchronous automata
   - Message passing automata: Also called Communicating finite-state machines
   - Lossy channel machines
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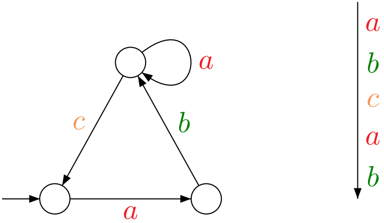
Automata



- Behaviours are words, i.e., sequences of actions over a finite alphabet $\Sigma = \{a, b, c\}$.

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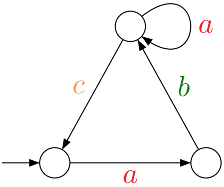

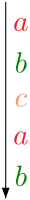

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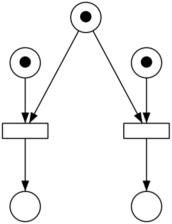
Questions

- How shall we distribute it?
- How shall we add concurrent behaviors?

Petri Nets

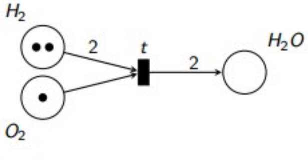


- An old model for distributed systems
  - invented by Carl Petri (-at the age of 13- in 1939? or '62)
  - to model resource consumption and so on...

Examples of Petri nets

- A chemical reaction: $2H_2 + O_2 \to 2H_2O$.
- A library
- A producer-consumer example
- A coffee machine

Examples of Petri nets



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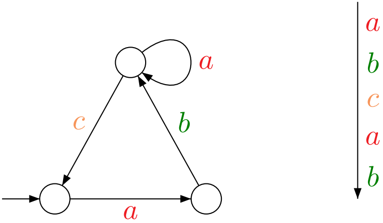

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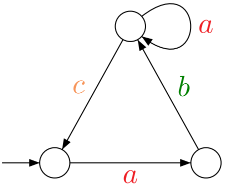

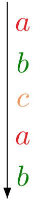

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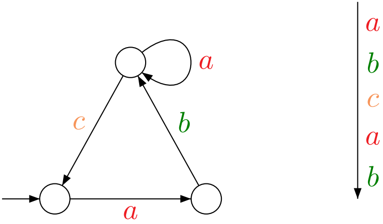
Asynchronous Automata



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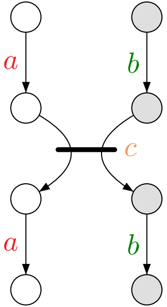
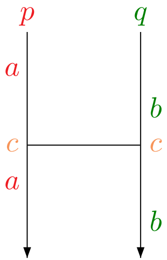
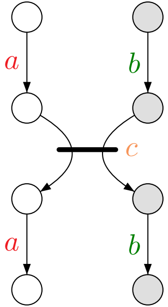
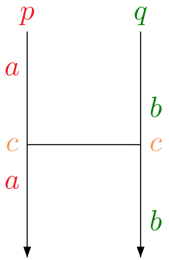




- Actions are distributed across processes (with sharing!)
- Some actions are shared, e.g., c is allowed only if both p and q move on c.

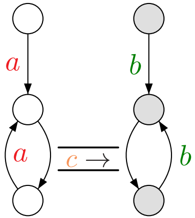
Asynchronous Automata

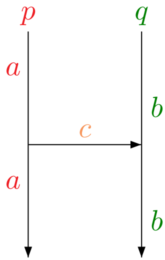




- What are the properties of languages accepted by such automata? E.g. above accepts $\{\underline{abcab}, bacab, bacba, abcba\}$.
- Given a language L, (when) can it be accepted by such an asynchronous automaton?

Message Passing Automata





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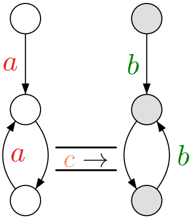
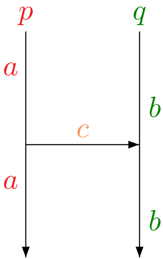
- We will consider decidability issues.

Message Passing Automata





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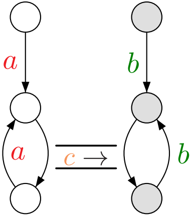

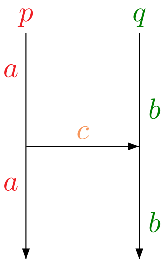

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- (Surprising fact: If you are allowed to lose messages randomly then it is decidable!) These are called Lossy channel systems.

Distributing automata

- Take products of automata with shared/communicated actions

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- Take products of automata with shared/communicated actions
- Consider local states and local transitions and see how they evolve

Generalizing...

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- Under-approximate verification
- Fixed-point approaches

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Pictures and Mathematics

- How do you write these objects mathematically?
- Why write them mathematically?

Some take-aways from this course

- Different formal models for distributed systems
- Mathematical formalisms that reason about (the infinite) behaviors of such systems.
- Techniques to automatically analyze such systems.
- How to use them and where they are applied.

Logistics

Evaluation (flexible... upto a point)

- Continuous evaluation - assignments/quizzes : 40%
- Exam (Midsem/Endsem): 35 %
- Paper presentation: 25 %

There will be guest lectures, research directions given along the way.

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Course material, references will be posted at

- `http://www.cse.iitb.ac.in/~akshayss/teaching.html`
- Piazza will be set up soon?