Temporal Action Language (TAL): A Controlled Language for Consistency Checking of Natural Language Temporal Requirements

(Preliminary results)

University of Kentucky

Department of Computer Science

Wenbin Li, Jane Huffman Hayes, Miroslaw Truszczynski

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The Problem

- Faulty requirements cause
  - 60% – 80% of project failures [1]
  - 80% of all software rework [2]

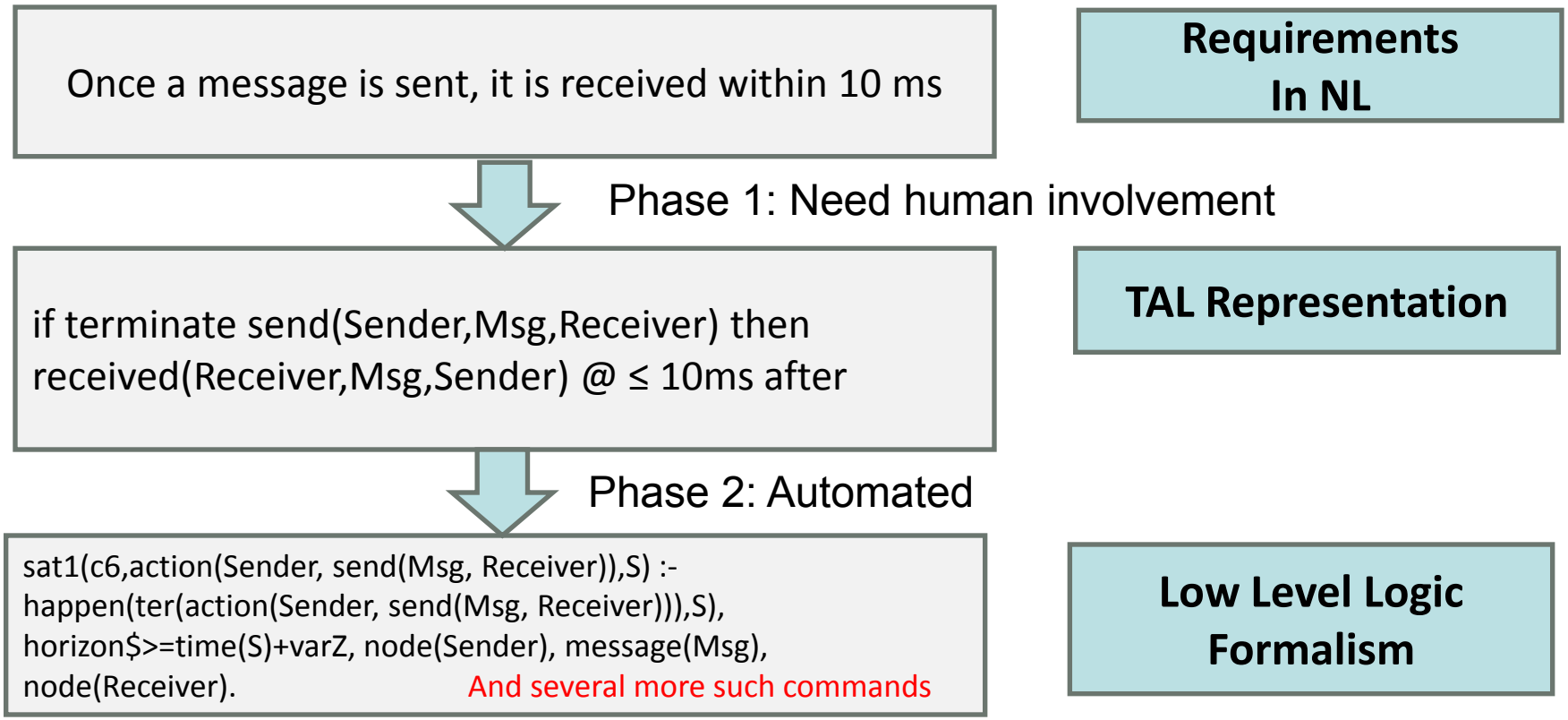
- Inconsistency : a common requirement fault
  - System contains nodes and a server.
  - Nodes A, B, and C must connect to the server *within the first 5 seconds*.
  - Connections cannot be established *simultaneously*.
  - It takes *2 seconds* to establish a connection.

Our Goal

- Detect inconsistencies
  - Focus on requirements stated in *natural language*
  - Focus on *temporal constraints*
- Minimize human involvement
- A language formal and human readable

Proposed Approach

- Temporal Action Language **TAL** as bridge



Temporal Action Language (TAL) Syntax

- Syntax
  - Declarations
    - sort node
    - fluent connected(nodeA, serA)
    - action sendMsg(nodeA)
  - Action Definitions: reuse AL (Baral, Gelfond 2000)
    - connect(*serA, nodeA*)

      causes *connected(nodeA, serA)* **if** *systemOn*
    - **impossible** *write(nodeA, serA)*

      if not *connected(serA, nodeA)*

Temporal Constraints

- < prompt | fluent > @ < when >
  - prompt: **commence** *Act* **terminate** *Act*

- Examples
  - **terminate** *dropConn(serA, nodeA)*
    @ ≤ 15 second **after startTime**

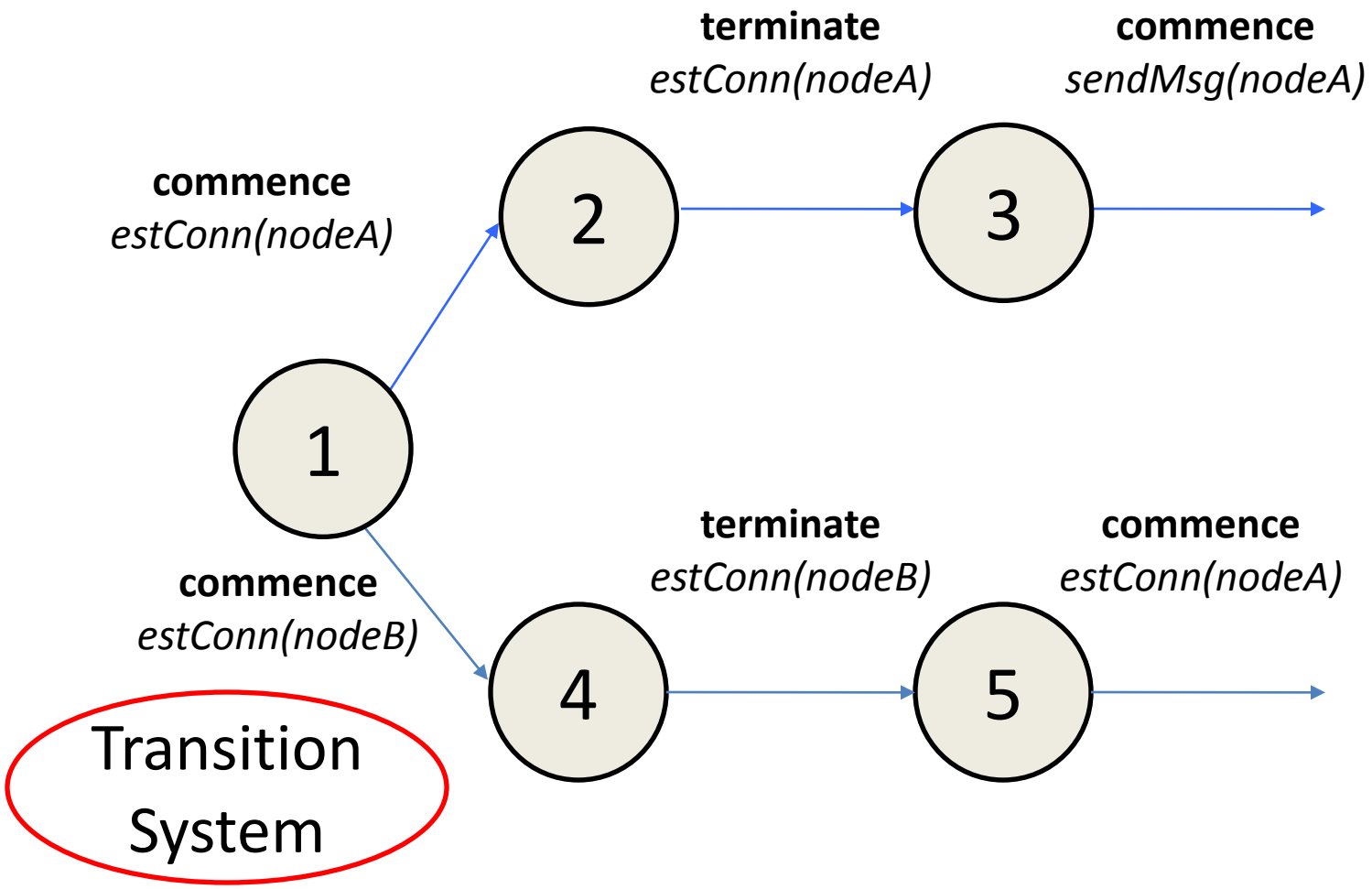
  - **commence** *sendMsg(nodeA)*
    @ ≤ 5 seconds **after terminate** *estConn(nodeA)*

  - *received(serA,message,nodeA)*
    @ ≤ 10 millisecond **after terminate** *send(nodeA, msg, serA)*

Temporal Action Language (TAL) Semantics

- Semantics
  - Transition system
    - States determined by fluents
    - Arcs labeled with prompts or “Time"
    - Illustrate all possible ways for system to evolve
  - Path
    - A particular scenario
  - Timed path
    - A scenario labeled with times when changes occur

Temporal Action Language (TAL) Semantics



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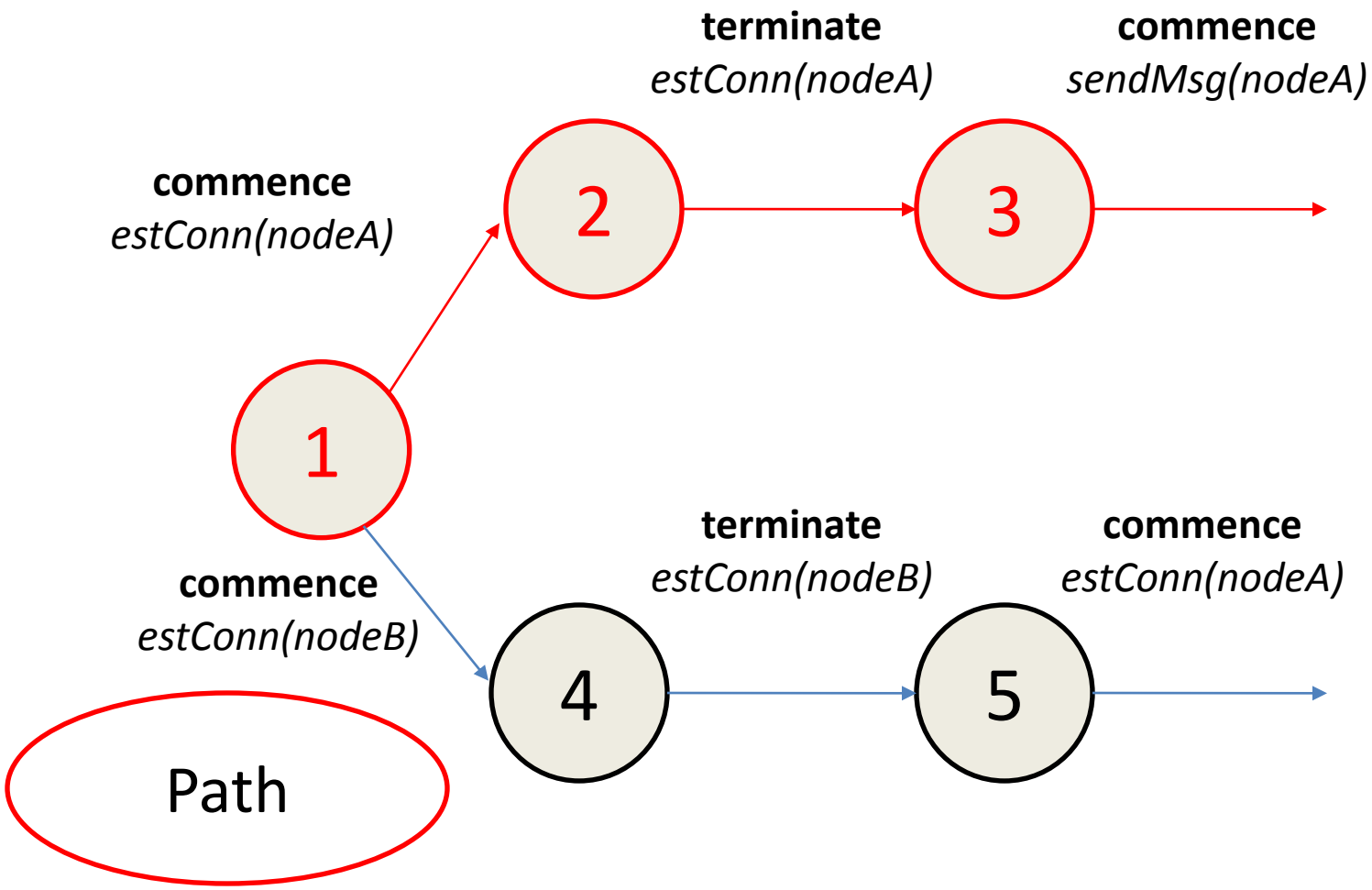

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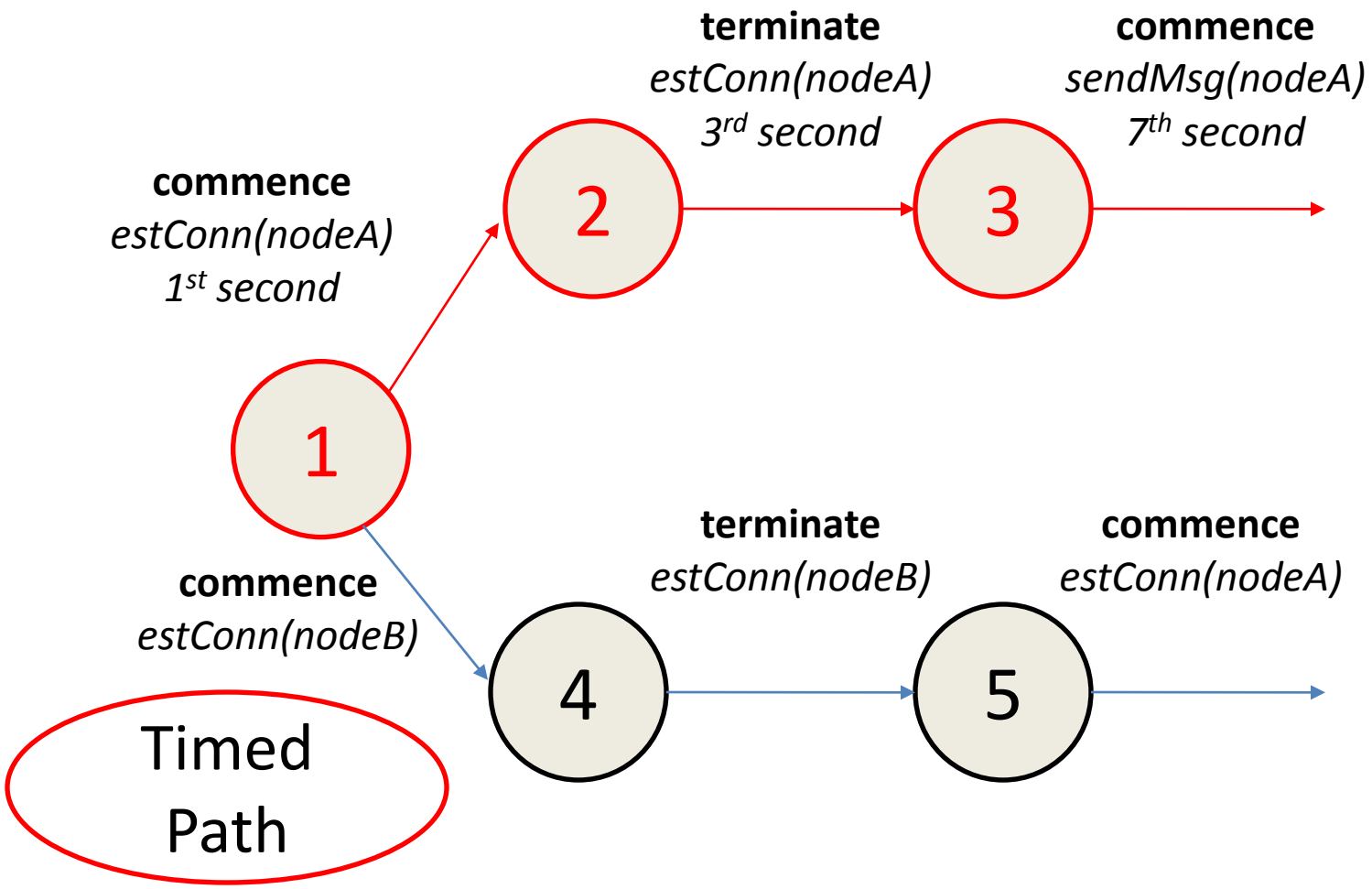

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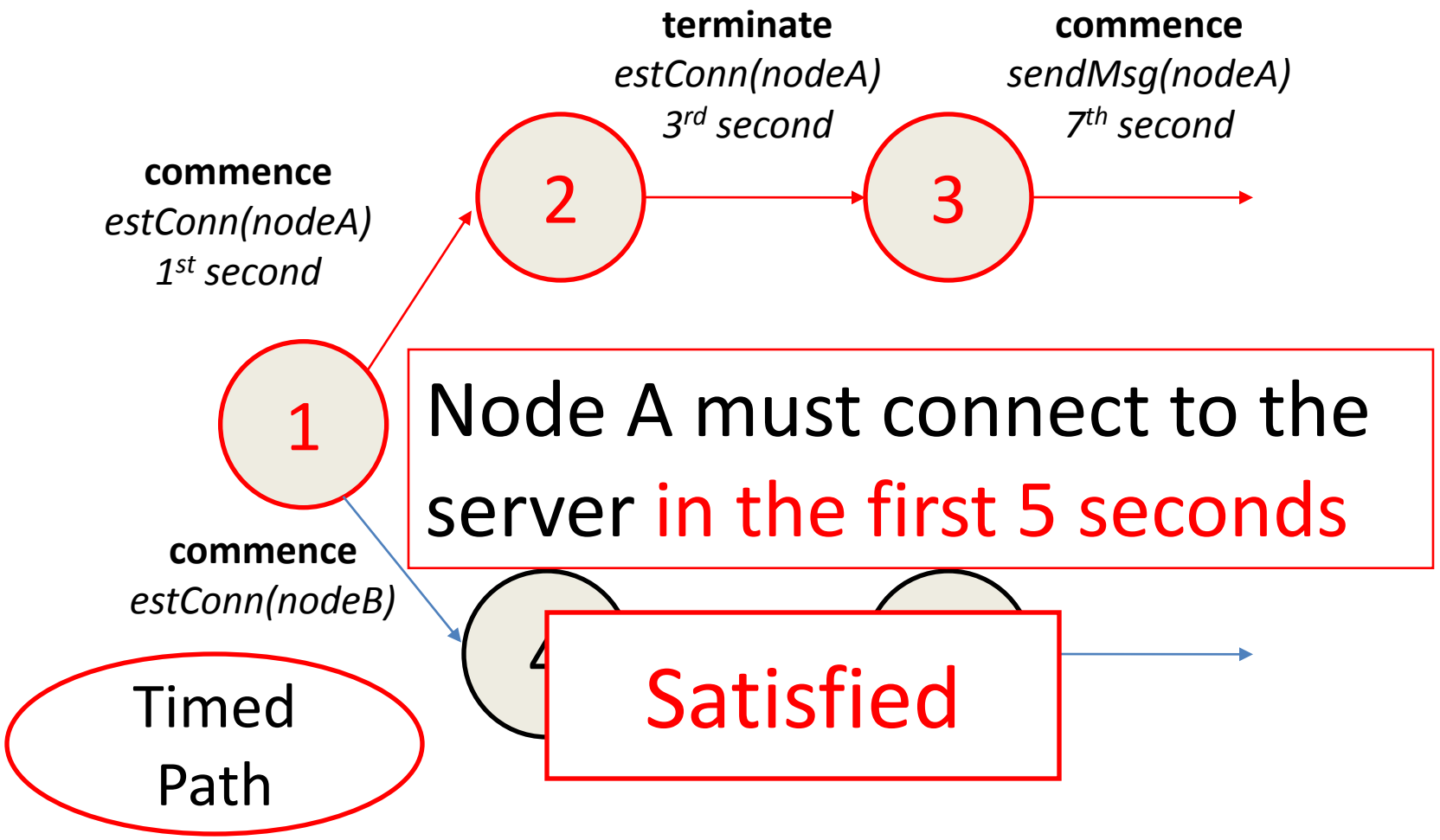

Temporal Action Language (TAL) Consistency Checking

- Valid timed path P
  - All temporal constraints satisfied along P
- Consistency
  - Arbitrarily long valid timed paths exist
  - Arbitrarily long system runs possible
- Limited consistency
  - Timed paths up to a certain time horizon
  - No inconsistency shows up prior to the horizon

Temporal Action Language (TAL) Consistency Checking

- To detect inconsistency search for a valid timed path
  - Translate TAL into low-level formal system
  - Use reasoning tools of that system

Validation

- So far:
  - Use NASA CM1 requirements
  - Generate a TAL theory for a subset of CM1 set that includes all temporal requirements
  - Translate that TAL theory into answer set programming (ASP)
  - Use ASP solver clingcon for processing

Related Work

- Software Cost Reduction
  - Heitmeyer, Labaw, and Kiskis, 1995 [6]
- Timed automata and temporal logic
  - Knapp, Merz, and Rauh, 2002 [7]
  - Bengtsson, Larsen, Larsson, Pettersson, and Yi, 1996 [8]
  - Bozga, Daws, Maler, Olivero, Tripakis, and Yovine 1998 [9]
- UML
  - Selic, 1998 [10]

Future Work

- From natural language to TAL
  - Partially automate generation of TAL theories from natural language text
- From TAL to low level logic formalism
  - ASP (Completed, but more work on translation optimization and performance needed)
  - Temporal logics
  - Timed automata
- Systematic experiments
- Seek broad feedback on TAL readability, design

References

[1] Bob Lawhorn, March 2010

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[3] C. Baral and M. Gelfond, “Reasoning agents in dynamic domains,” Logic-based artificial intelligence, pp. 257–279, 2000

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[10] M. Bozga, C. Daws, O. Maler, A. Olivero, S. Tripakis, and S. Yovine, “Kronos: A model-checking tool for real-time systems,” LECTURE NOTES IN COMPUTER SCIENCE, pp. 298–302, 1998.

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Thank you!

Questions?