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Automatic Generation of Goal-Tree from Statecharts Requirements Specification

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Towards Automatic Generation of Fault Trees from Statecharts Requirements Specification

- Statecharts
- An Example: KNICS DPPS Trip Logic
- Related Work
- Proposed Approach
- Conclusion and Future Work

Work in progress...

Statecharts

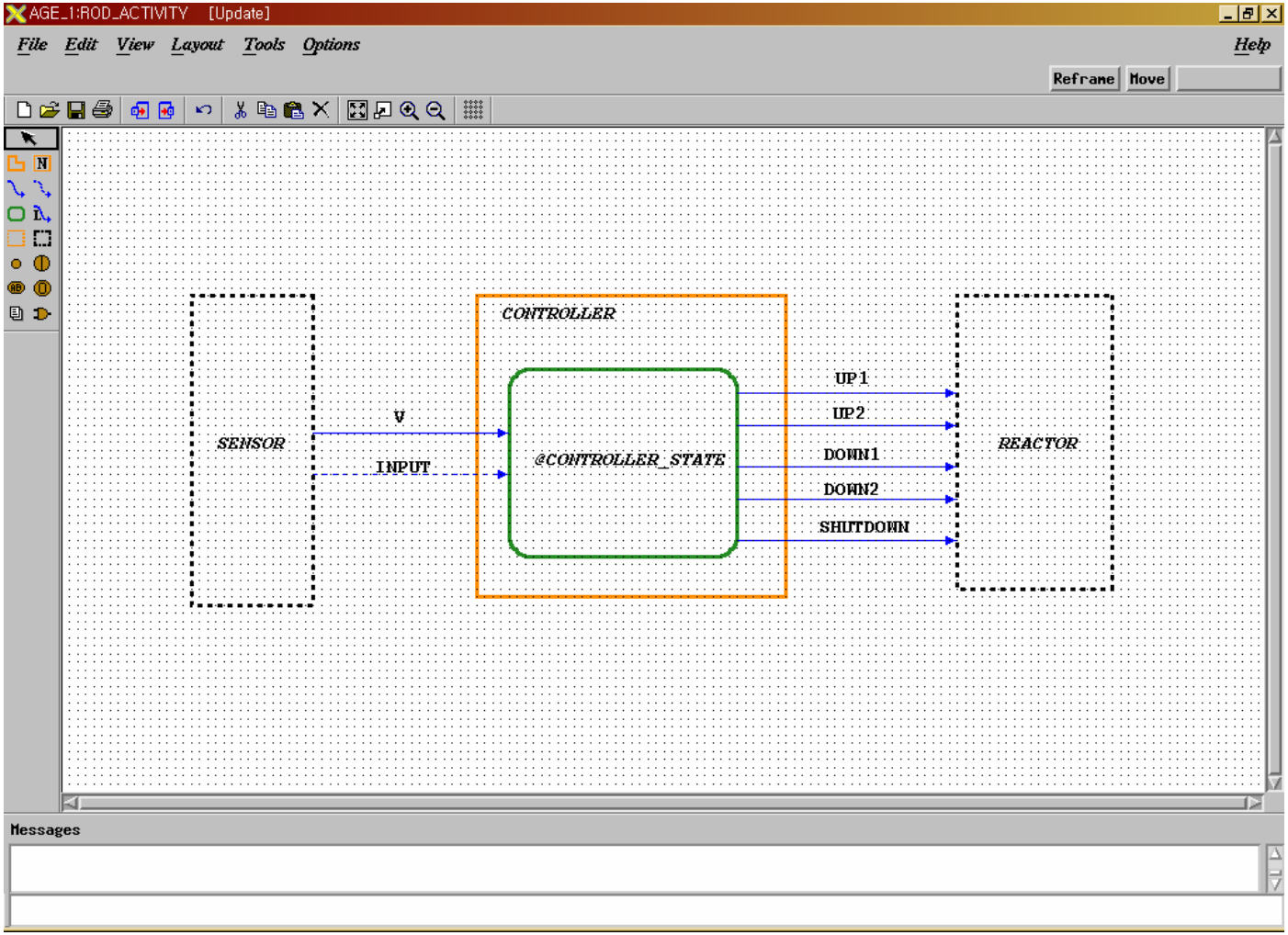
- Formal and visual requirements specification language
  - Activity Chart + Statechart + Module Chart

- Widely used for reactive systems
  - Hierarchical Structure
  - Concurrency
  - Broadcasting

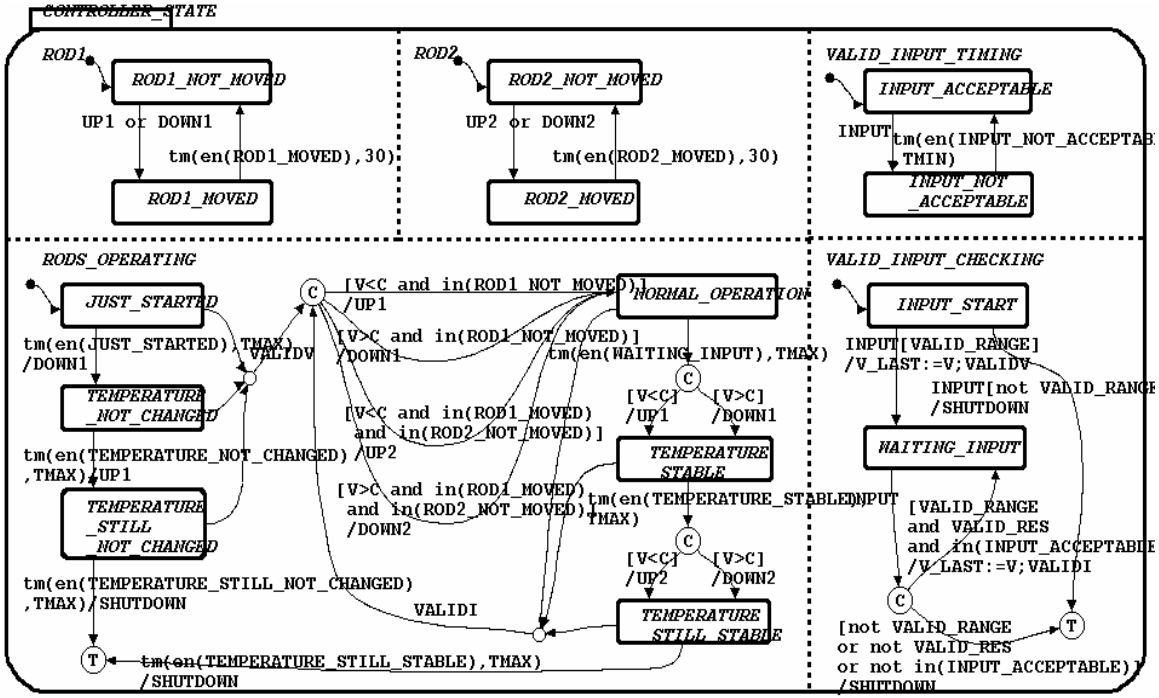
Statemate:

- Graphical editors, data dictionary, simulator, model checker, …

Statemate and Activity Chart



Statemate and Statecharts



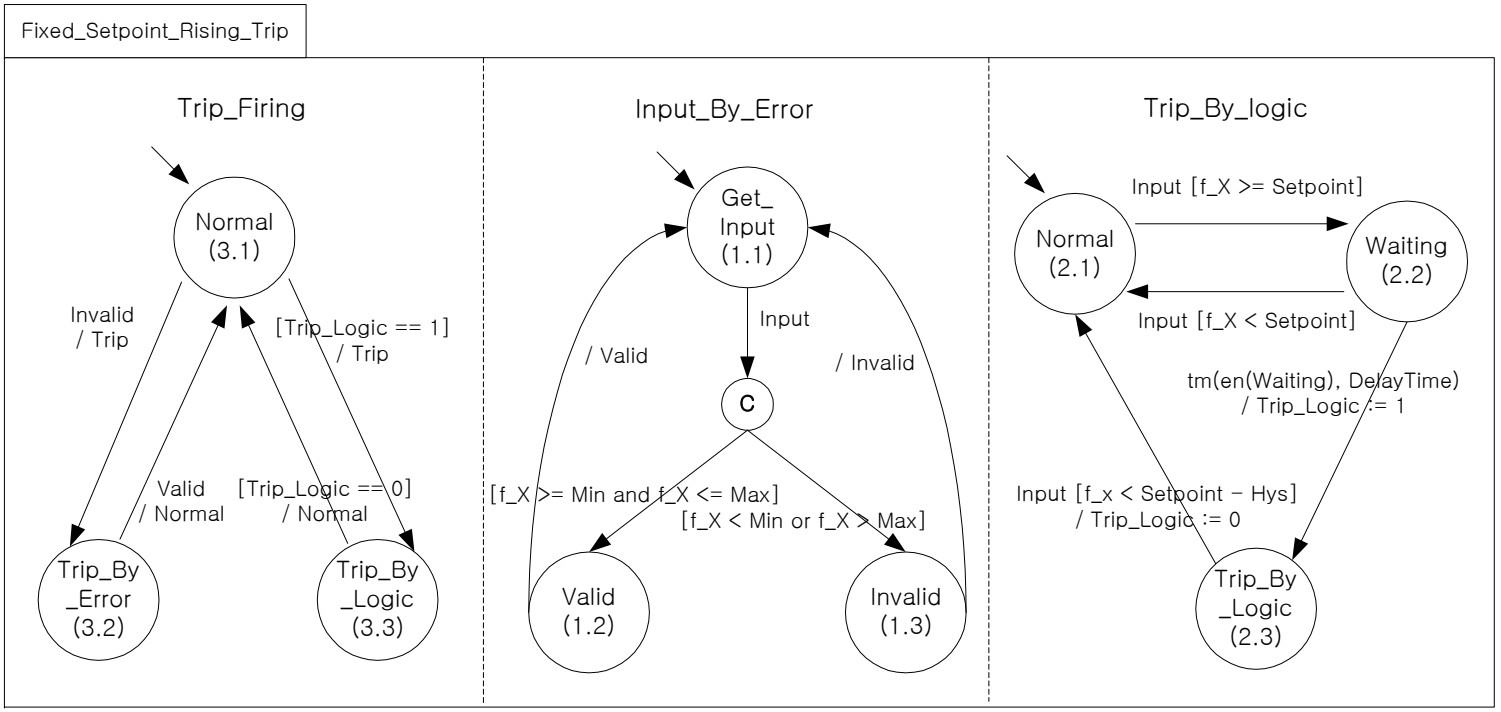
In KNICS project, Statecharts are being used to specify SRS for ESF-CCS, PLC application software, …

KINS, regulatory body, requires safety analysis(FTA) on SRS.

KNICS DPPS RPS BP Trip Logic

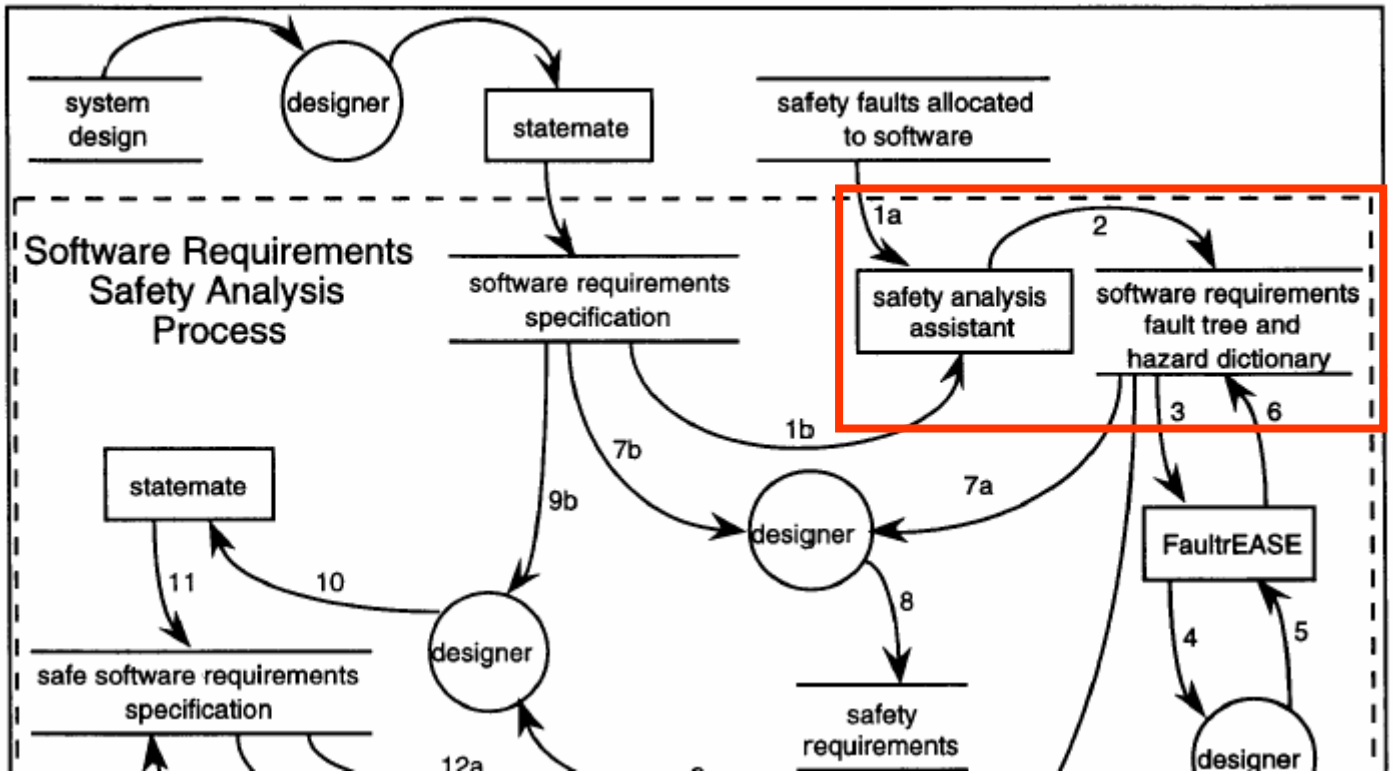
Fixed Set-Point Rising Trip logic (simplified)

- Trip_By_Logic : If trip condition is continued for predefined time
- Trip_By_Error : If external input data has invalid value



Related Work: [Mojdehbakhsh, et al. (1994)]

- Primarily concerned with how overall software requirements safety analysis process is to be applied



Related Work: [Mojdehbakhsh, et al. (1994)]

5. For each entity identified in 3.2 do the following:
   - 5.1. Create an AND node labeled event.x where x = 1..n. Connect this node as a child to the node created in 1.
   - 5.2. Set the right child of this node to in(state-name)
   - 5.3. Create an OR node for the left child labeled event.trigger
   - 5.4. Identify all actions in this entity that generate the event.
   - 5.5. Identify all independent triggers of these actions.
   - 5.6. Assign the items in 5.5 as the children of the node in created 5.3.

- No concrete guidelines are given as to how steps 5.4 and 5.5 could be applied systematically

Related Work: [Mojdehbakhsh, et al. (1994)]

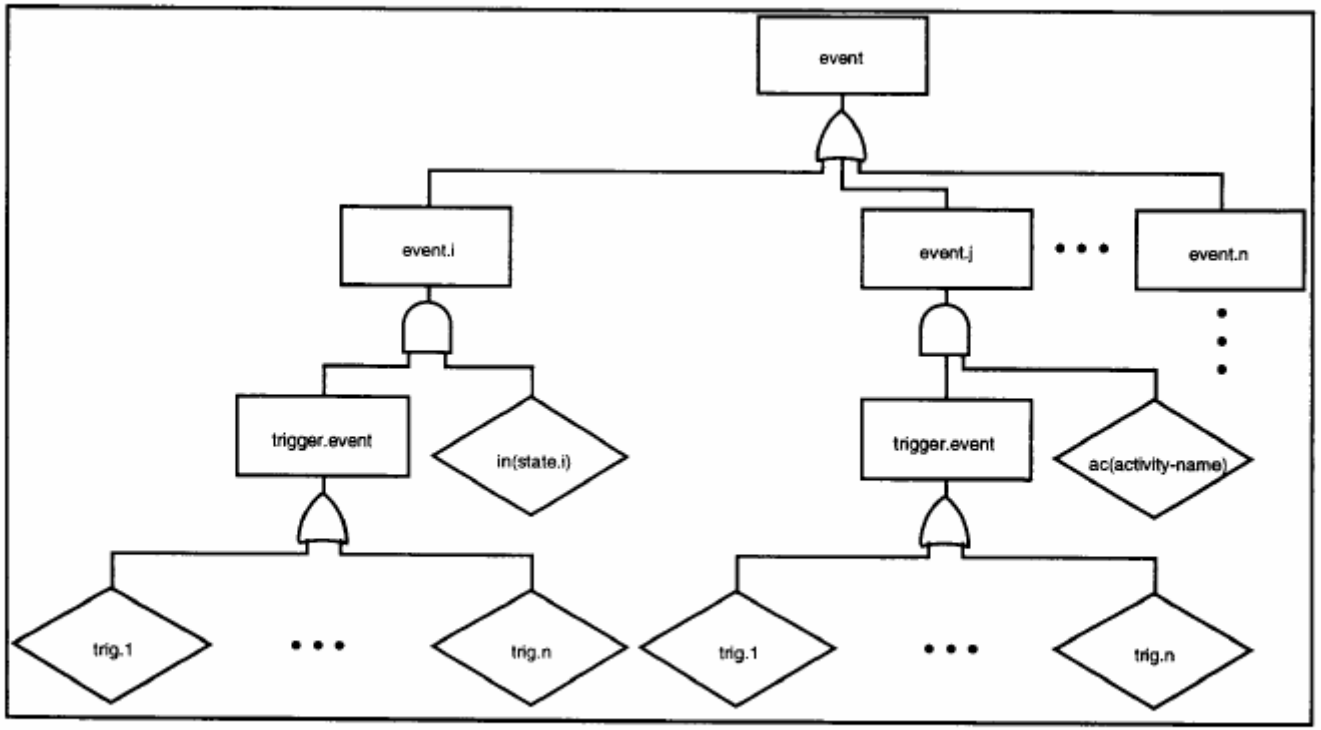


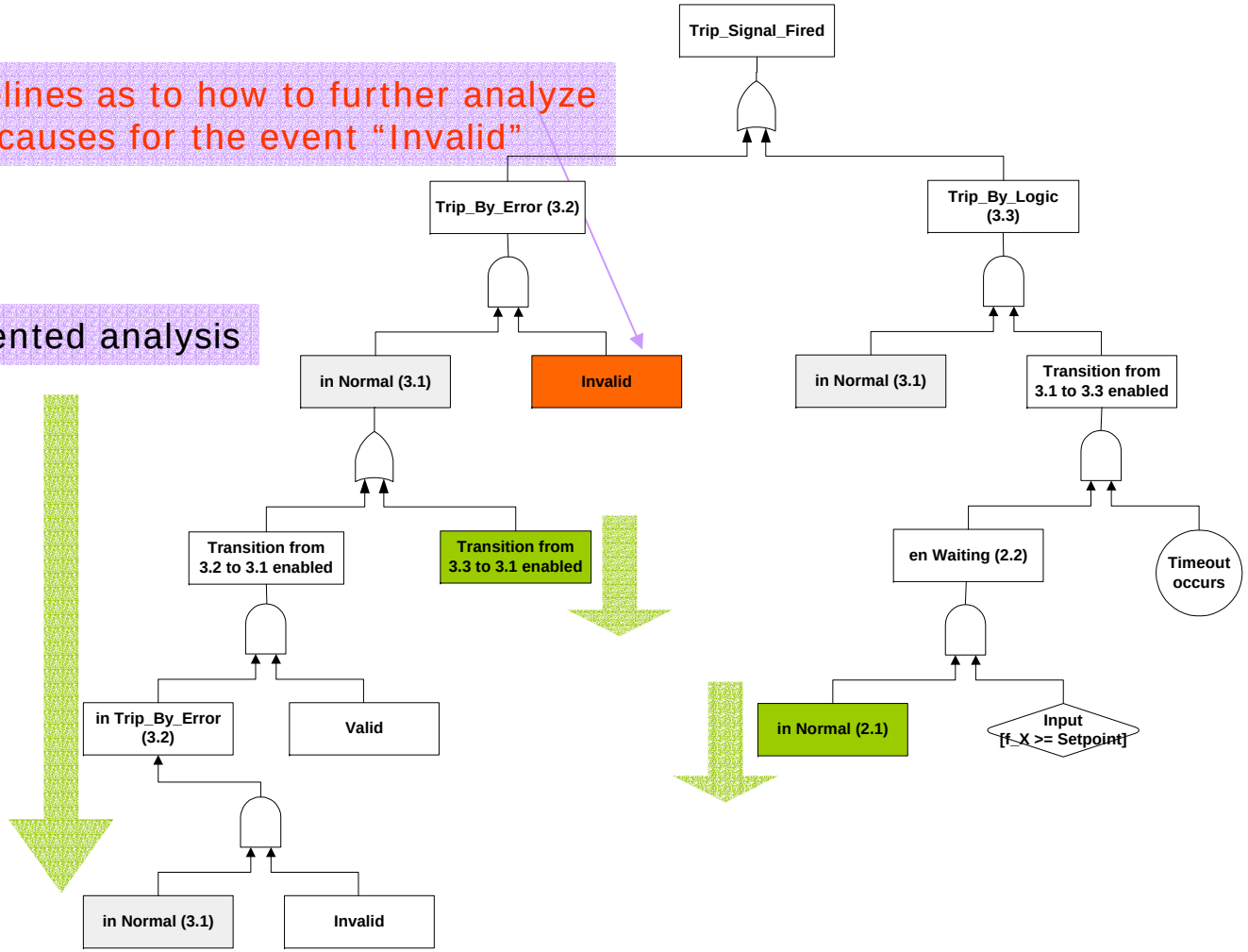
Figure 5. Template for single primitive event. The three dots represent repetition of nodes. The left branch of the tree is a template for entities in rule 3.2, and the middle branch for those in 3.1. There can be as many event.n nodes as required for both 3.1 and 3.2 type entities.

Related Work

FT Generated by [Mojdehbakhsh, et al. (1994)]

No guidelines as to how to further analyze credible causes for the event “Invalid”

State-oriented analysis



Related Work: [Ratan, et al. (1996)]

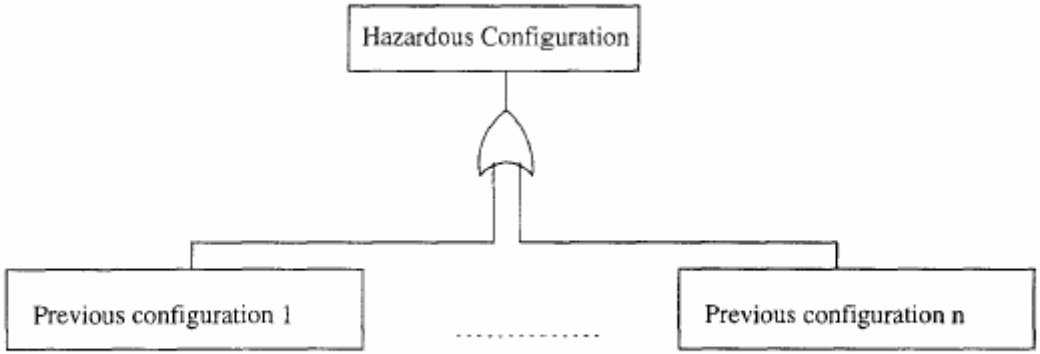


Figure 5. *Basic template for each level of fault tree.*

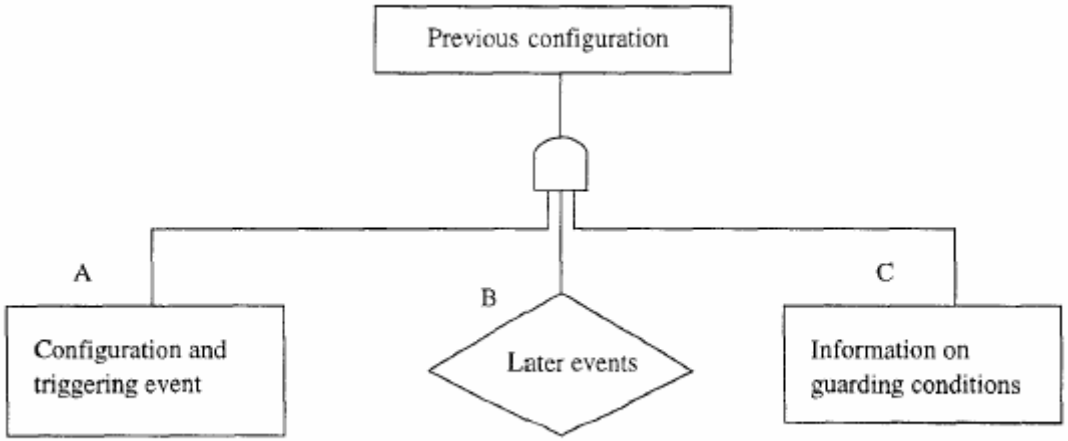
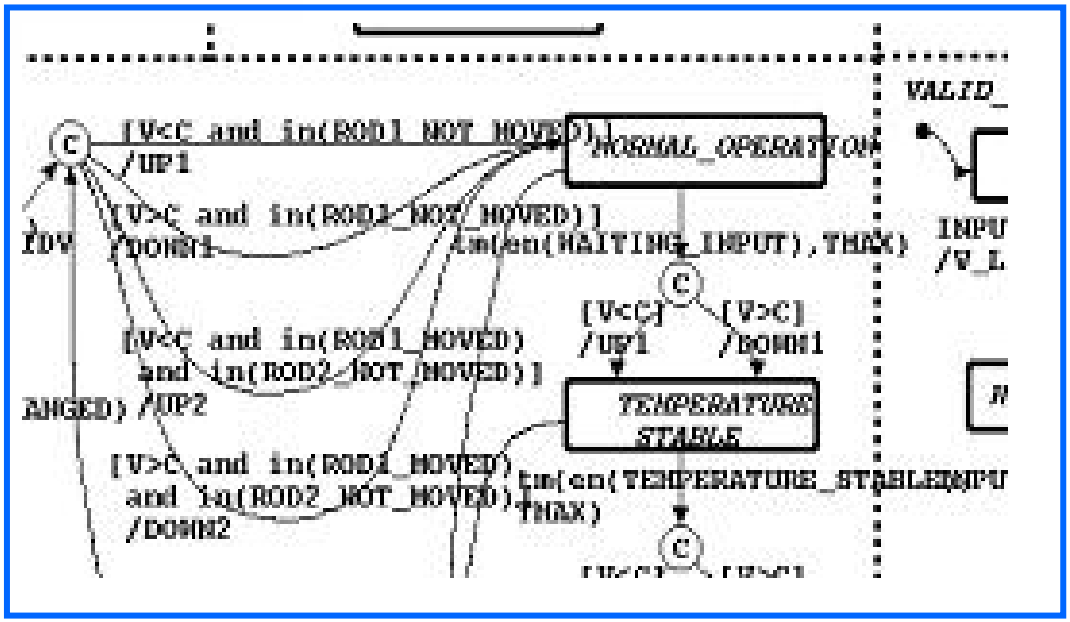


Figure 6. *Expansion of a previous configuration node.*

Related Work: [Ratan, et al. (1996)]
RSML vs Statecharts

		OR	
AND	Position **In State** Single	·	T
	Distance **In State** IP	T	T
	ThisLaneFront	T	·
	OwnSpeed = System_Speed	F	T

Figure 3. *An AND/OR table.*



Related Work: [Ratan, et al. (1996)]

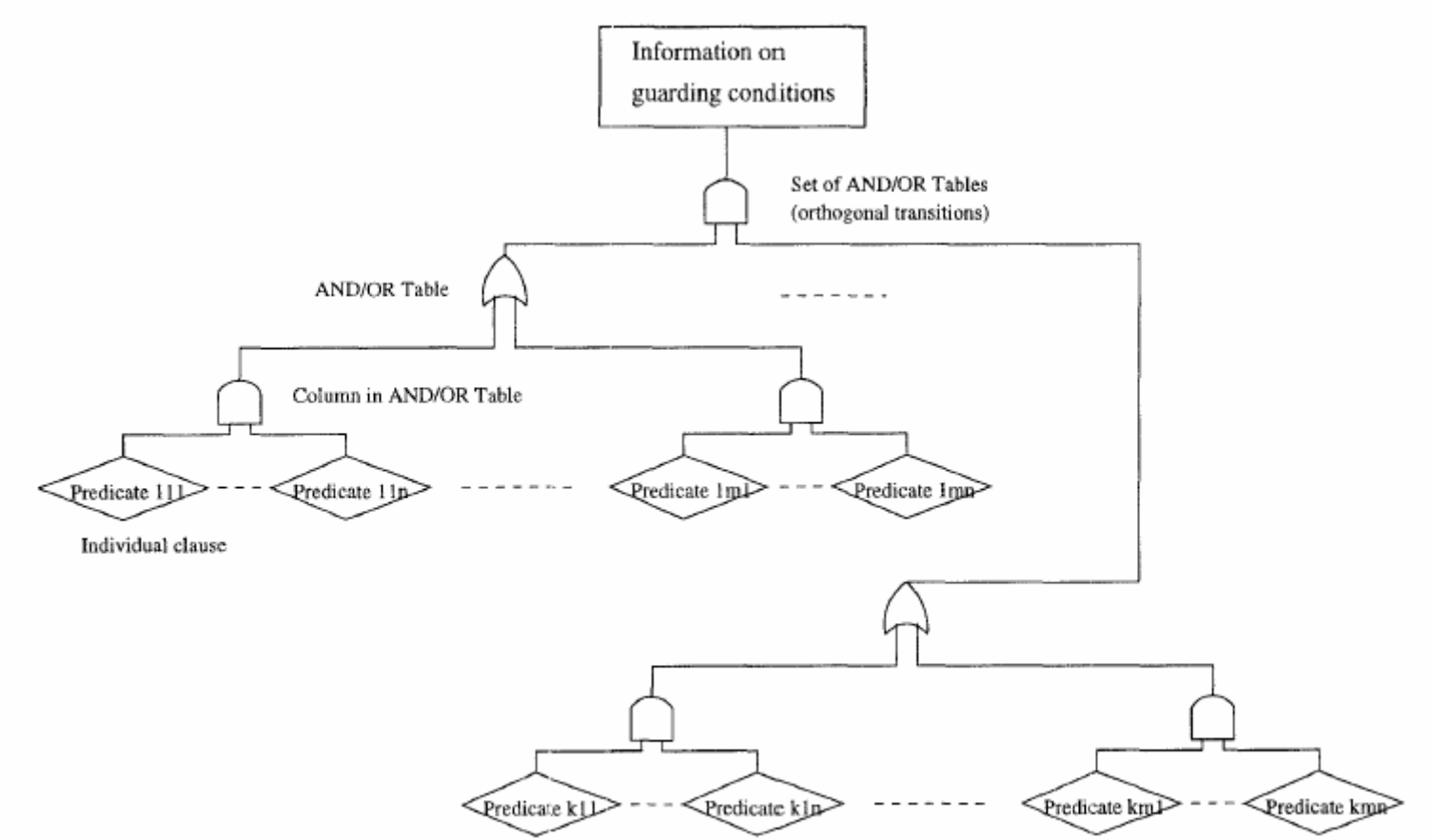
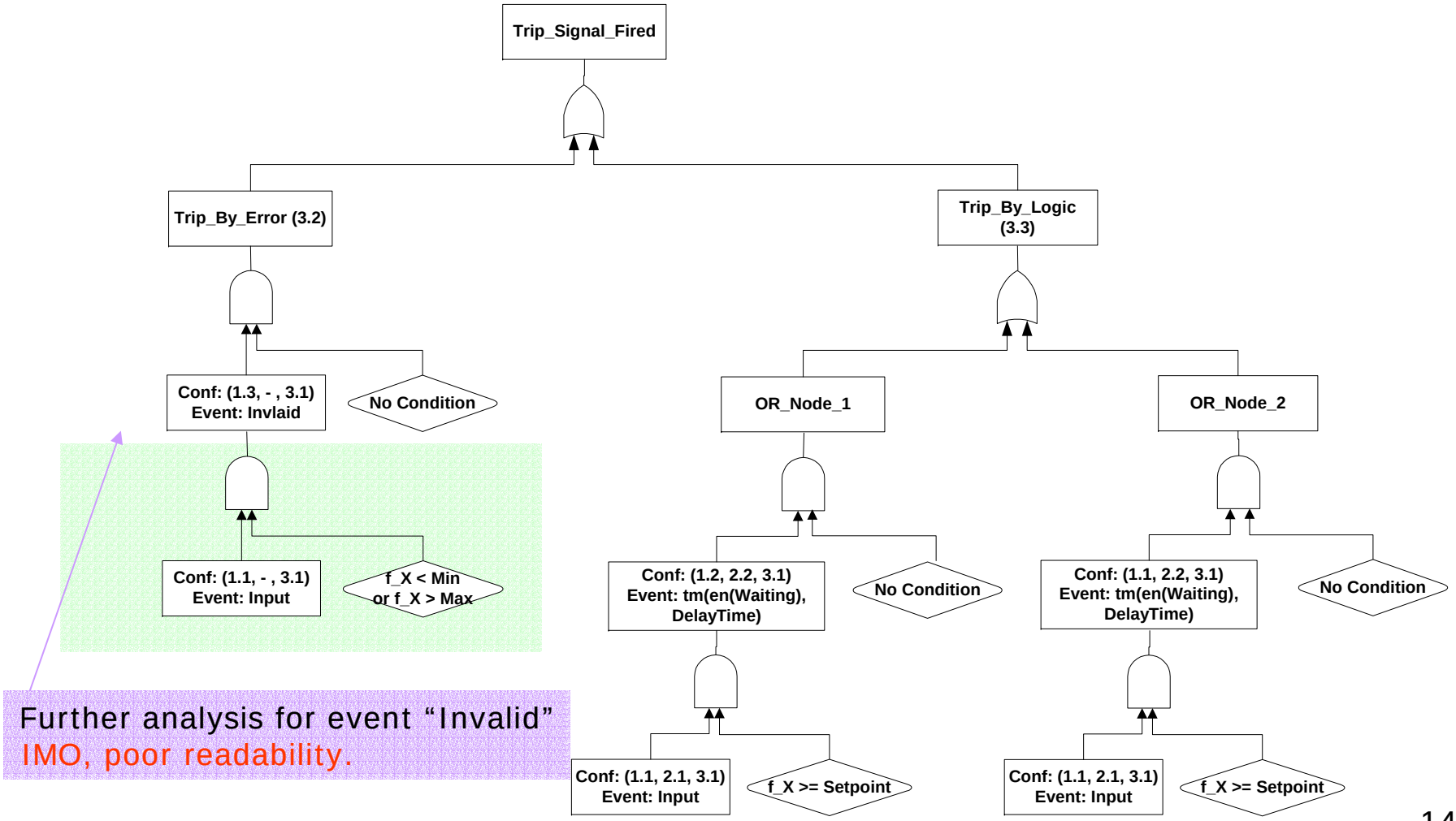


Figure 7. *Expansion of guarding conditions information node.*

Related Work

FT Generated by [Ratan, et al. (1996)]

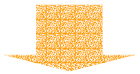


Further analysis for event “Invalid”
IMO, poor readability.

Proposed Approach

Step 1
Pre-processing
(done manually)

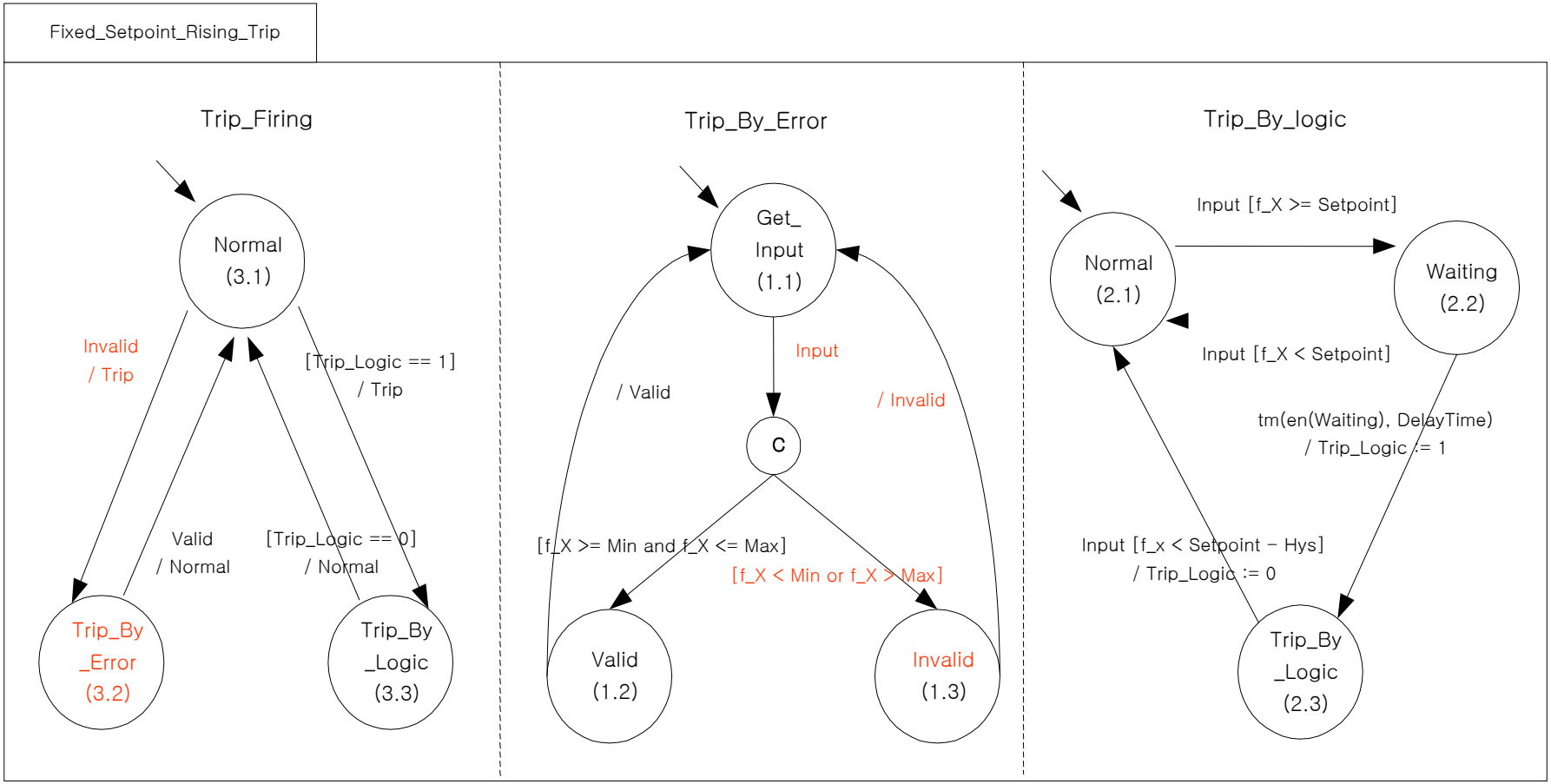
Identify external activity(s)
Select the top-level event



External activity(s) : event *Input*, data *f_X*
Top-hazard event : *Trip due to Invalid Event*

Proposed Approach

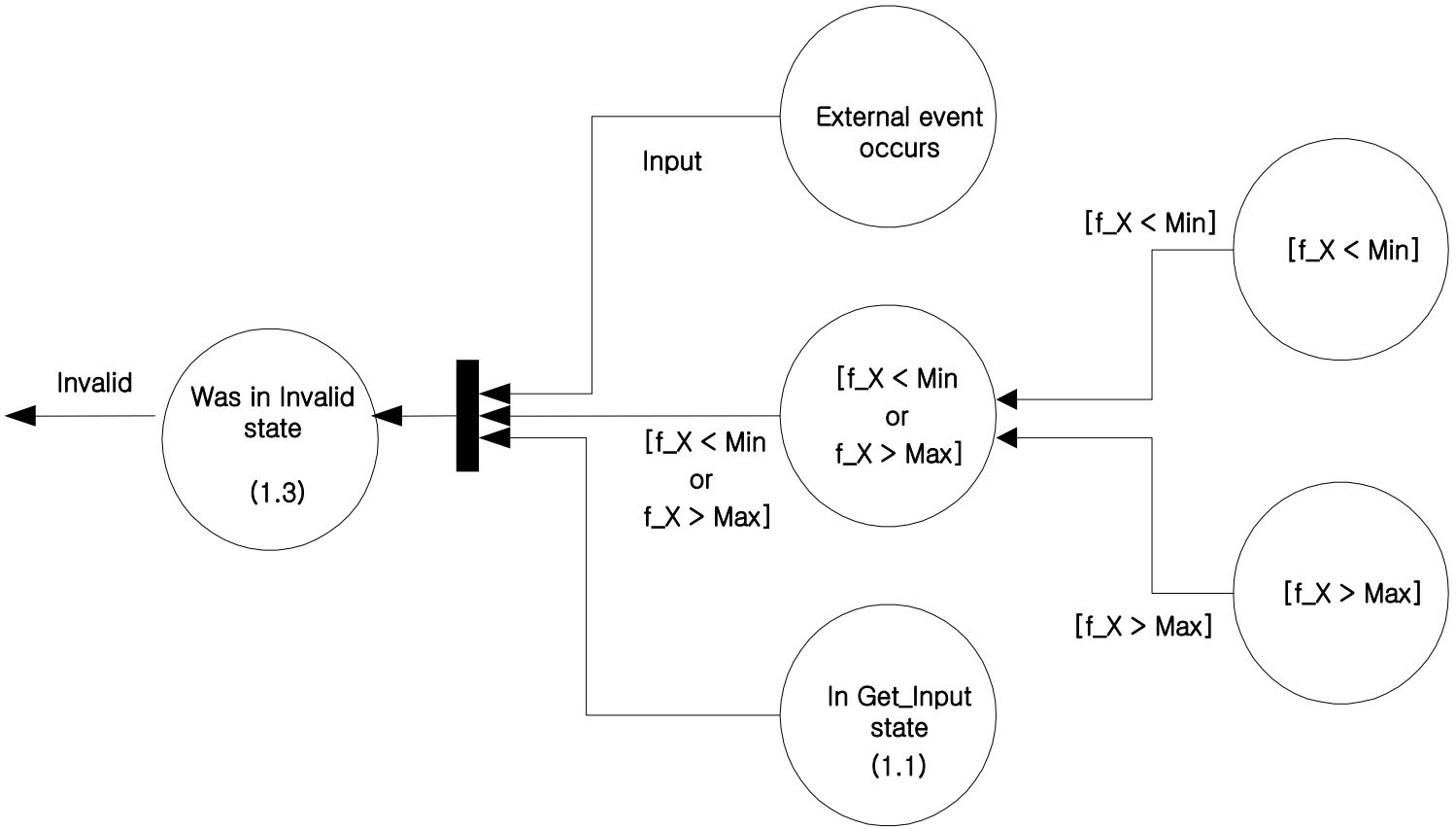
Step #2: Transform Statecharts to …



*** Dependency analysis, program slicing**

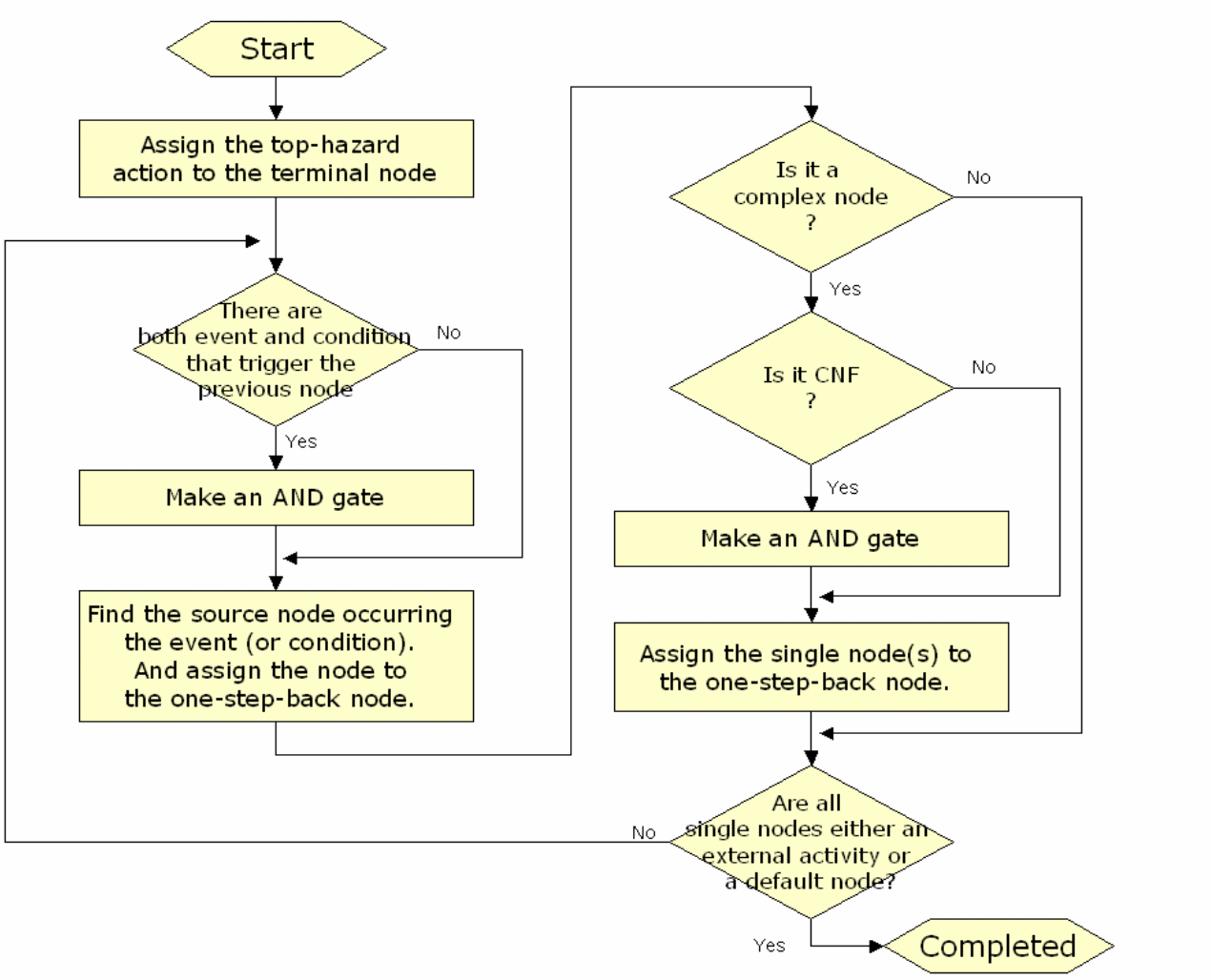
Proposed Approach

Step #2: Statecharts -> Labeled Digraph



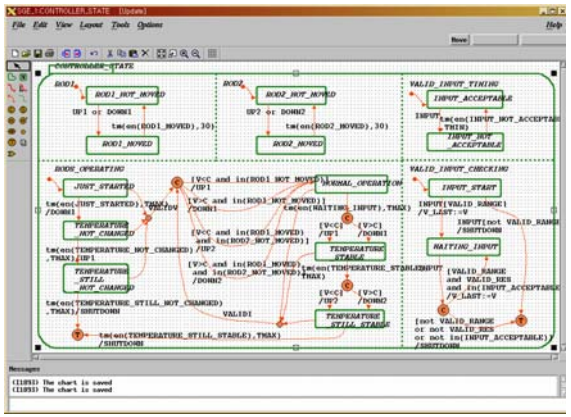
Systematic Event-based Fault-Tree Generation

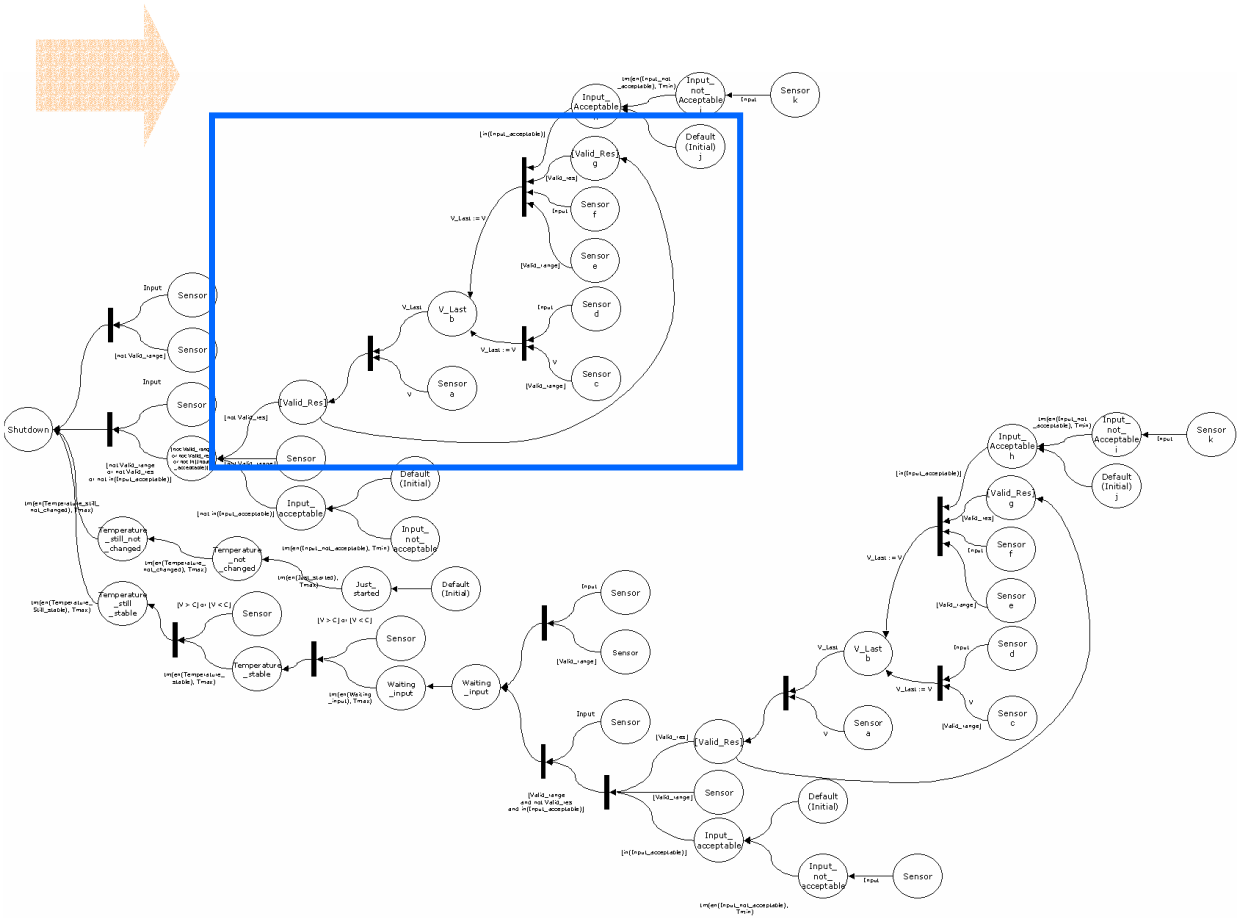
Step 2: Statecharts → Labeled Digraph



Systematic Event-based Fault-Tree Generation

Step 2: Statecharts → Labeled Digraph

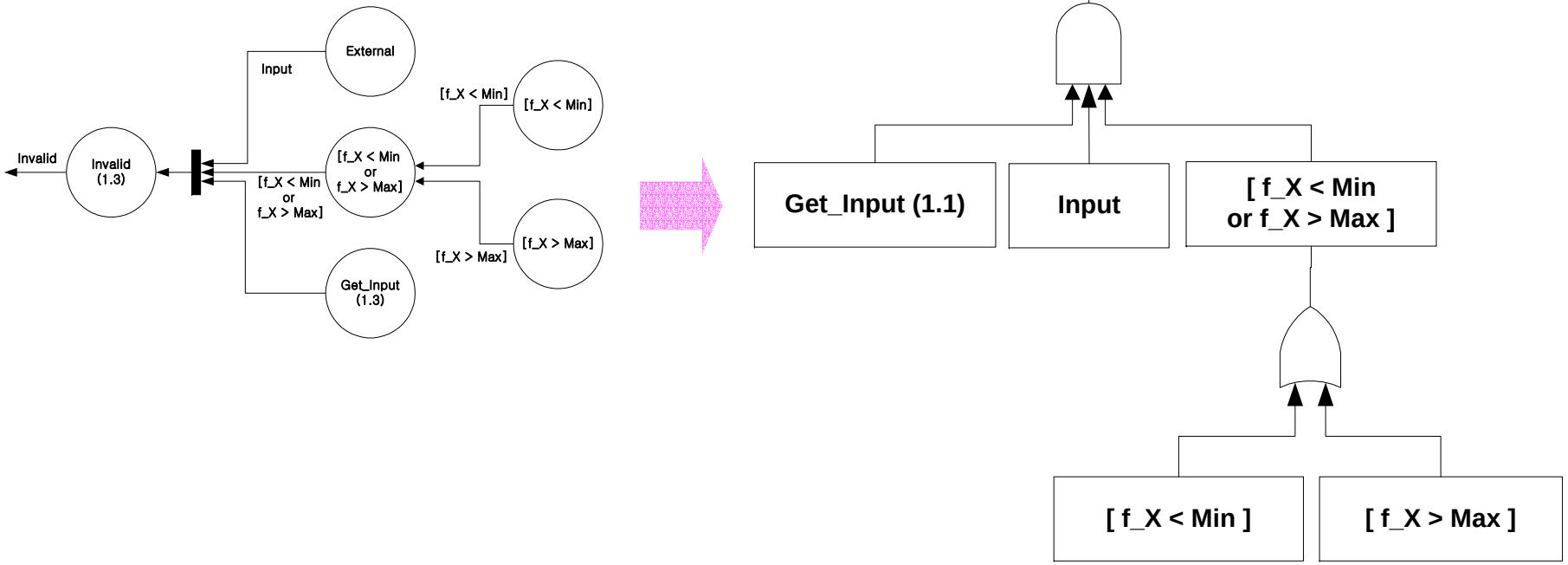




Proposed Approach

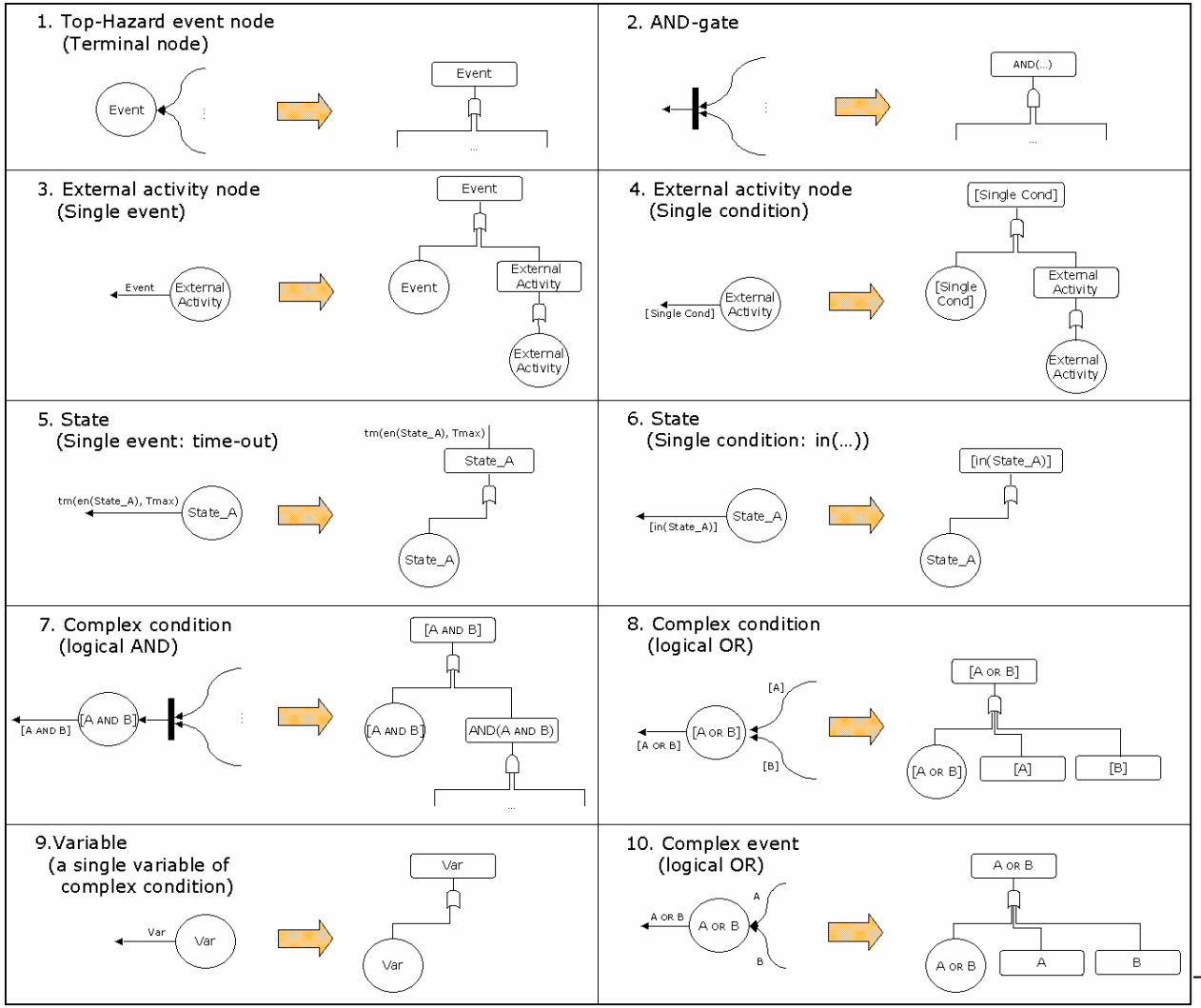
Step 3: Labeled Digraph to Fault Tree

Step 3
Labeled Digraph → Fault-Tree



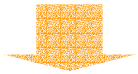
Systematic Event-based Fault-Tree Generation

Step 3: Labeled Digraph → Fault-Tree Patterns



Systematic Event-based Fault-Tree Generation

Step 4: Fault Tree Reduction, Cycle Resolution, ...



Step 4

"Macro definition" of common fault trees,

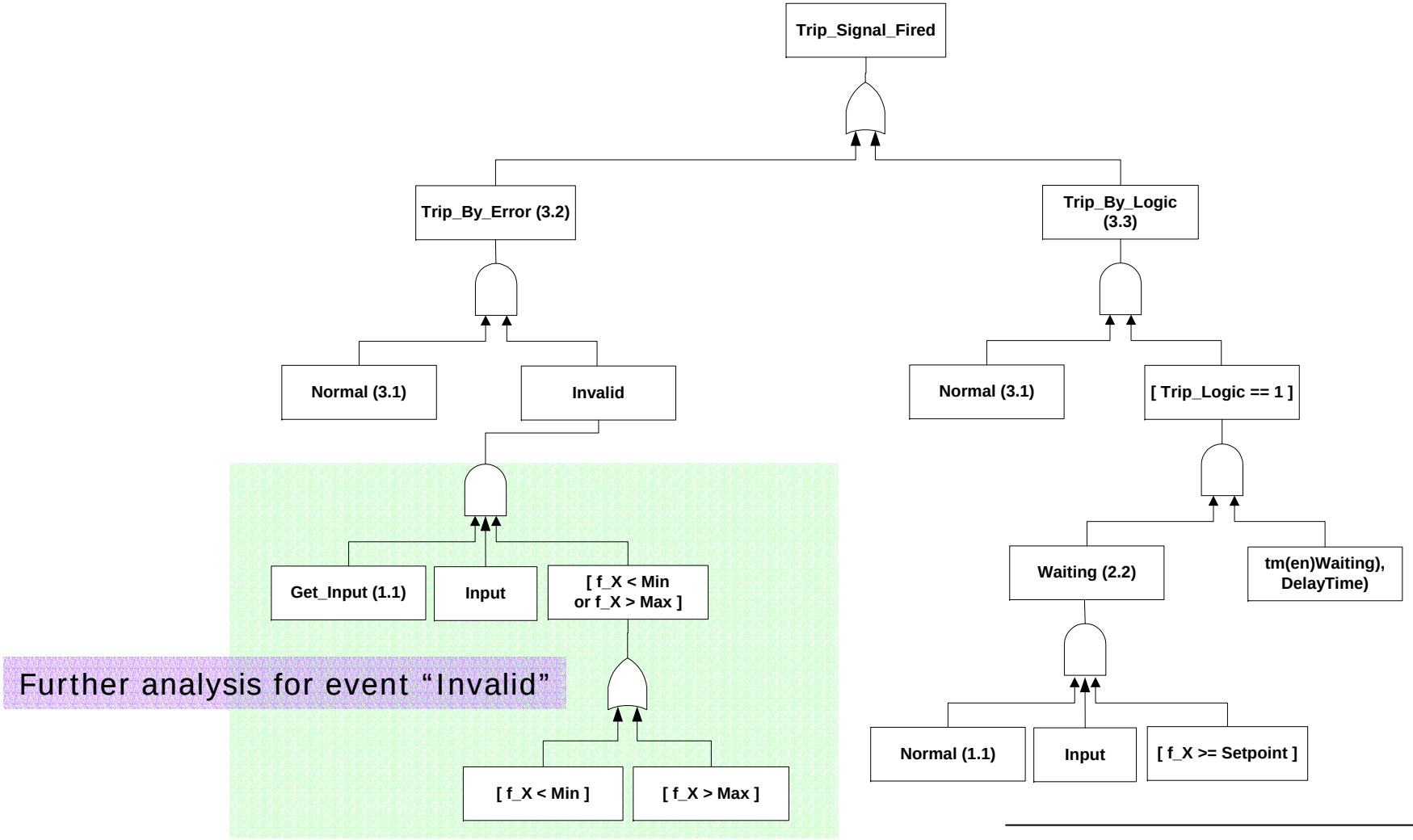
Resolution of cyclic fault trees
(primarily because Statecharts are most likely to exhibit cyclic system behavior),

Minimal cut-set analysis,

...

Proposed Approach

FT Generated by Proposed Approach



Summary

We’re trying to propose a systematic process for developing fault-tree from Statecharts.

- “More than ‘too-elementary-to-be-useful’ guidelines”

- “Improved understandability”

- Backward analysis becomes quite complex when “domino effects” and complex guarding conditions are considered

Accuracy of fault tree can be easily (albeit manually) verified by human experts

Future Work

Process is not yet fully refined/automated

Critical (and empirical) comparison of competing approaches by **domain experts**