# Specification and Analysis of Requirements (SpeAR) Tool

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## What is SpeAR?

SpeAR is a functional requirements development framework with the following features:

- Formalisms to help users express requirements unambiguously.
- Domain-specific language to capture the contextual information.
- Constraint based analysis of formalized requirements against a set of validating properties.

## What isn't SpeAR?

- A detailed design tool.



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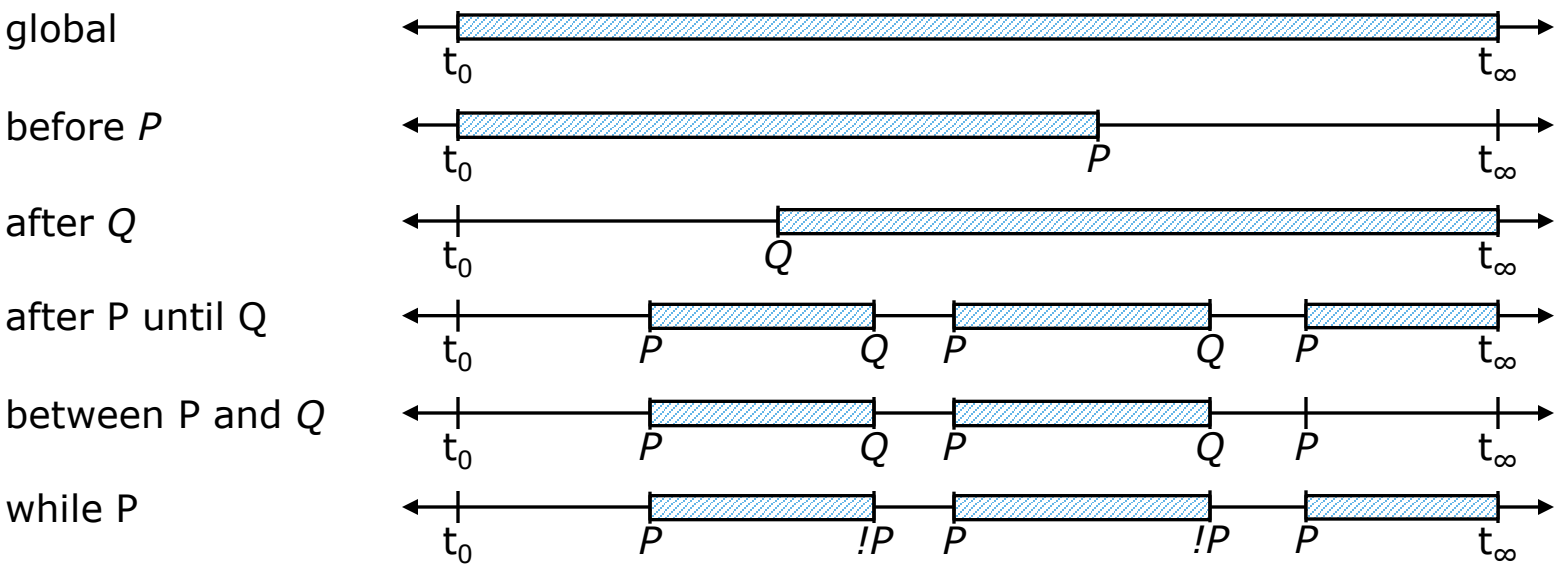
# Formalizing Requirements in SpeAR

Spear formalizes requirements using the specification patterns developed at Kansas State University.

http://patterns.projects.cis.ksu.edu/

## Scopes



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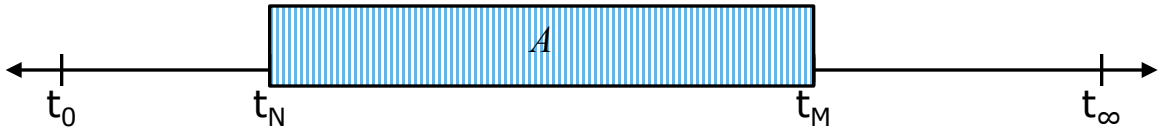
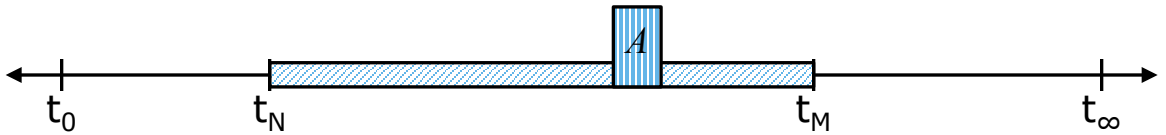
# Predicates

always *A*



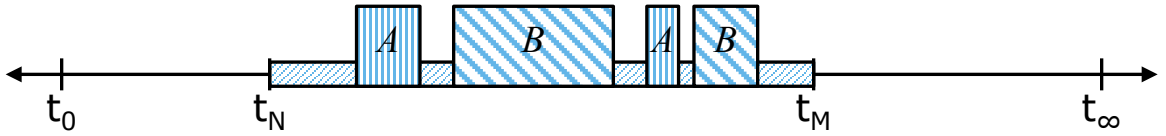

On the scope starting at $[t_N, t_M)$ A must always hold.

exists *A*



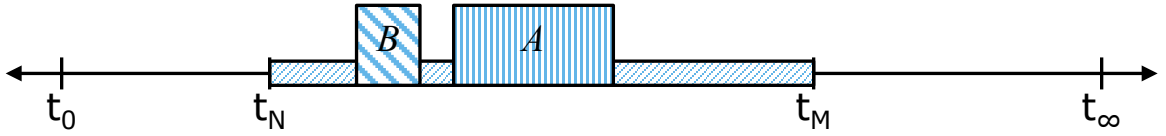

On the scope $[t_N, t_M)$ A must hold at least once.

*A* precedes *B*




On the scope $[t_N, t_M)$ every occurrence of B must be preceded by an occurrence of A.

*A* reponds *B*




On the scope $[t_N, t_M)$ every occurrence of B must be followed by an occurrence of A.



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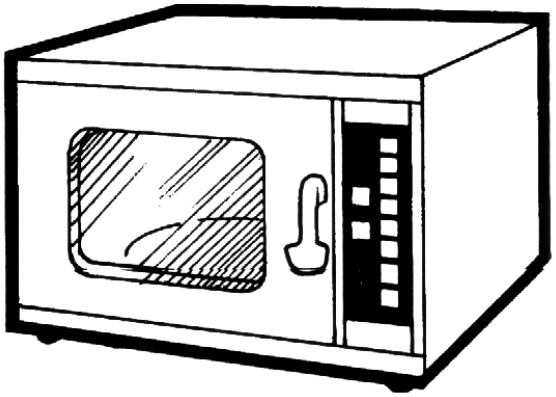
# Microwave Example

To illustrate the use of these patterns consider the example of a microwave oven. Describing the requirements of a microwave oven can be done in SpeAR.

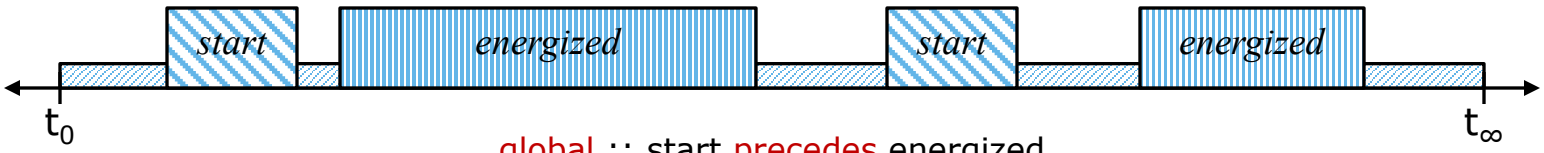
***Inputs***

start
clear
door closed

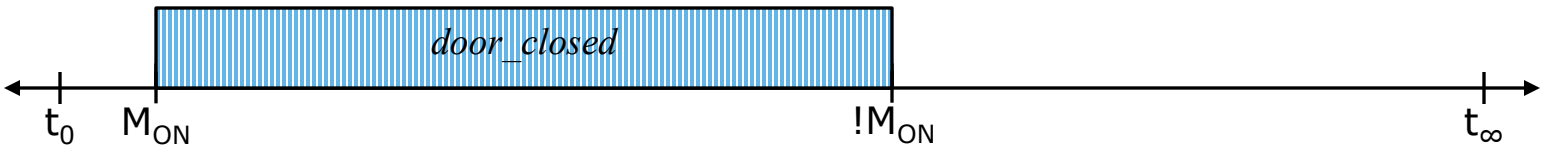


***Outputs***

energized
time_remaining




global :: start precedes energized




while energized ($M_{ON}$) :: always door_closed



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# Domain Specific Language

SpeAR specifications are captured in a a domain specific language that requires explicit interface, assumptions and requirements definitions.

mode_logic.spear | equals.spear

```
package microwave.mode_logic;

procedure mode_logic(clear,start,door_closed,seconds_to_cook) returns (output);

import microwave.definitions.*;
import microwave.definitions.mode_type;
import microwave.definitions.mode_type.*;
import microwave.definitions.modelogic_output_type;

Units:
    seconds;

State:
    clear : bool;
    start : bool;
    door_closed : bool;
    seconds_to_cook : int seconds;

    seconds_remaining : int;
    mode : mode_type;

    output : modelogic_output_type;

Requirements:
    a0 = global :: always (second_to_cook >= 0 seconds);

    r0 = initial :: (mode == SETUP) and (seconds_remaining == 0 seconds);

    r1 = after (pre mode == SETUP) :: (mode == SETUP) responds (not start or clear or seconds_to_cook <= 0 seconds);
    r2 = after (pre mode == SETUP) ::
        ((mode == COOKING) and (seconds_remaining == seconds_to_cook)) responds ( start and not clear and door_closed and seconds_to_cook > 0 seconds);
    r3 = after (pre mode == SETUP) ::
        ((mode == SUSPENDED) and (seconds_remaining == seconds_to_cook)) responds (start and not clear and not door_closed and seconds_to_cook > 0 seconds);

    r4 = after (pre mode == COOKING) :: ((mode == COOKING) and seconds_remaining == pre seconds_remaining - 1 seconds) responds
        ((pre mode == COOKING) and (door_closed and not clear and seconds_remaining > 0 seconds)) ;
    r5 = after (pre mode == COOKING) :: (mode == SUSPENDED) responds (not door_closed or clear and (seconds_remaining > 0 seconds));
    r6 = after (pre mode == COOKING) :: (mode == SETUP) responds (seconds_remaining <= 0 seconds);

    r7 = after (pre mode == SUSPENDED) :: (( mode == SUSPENDED ) and (pre seconds_remaining == seconds_remaining)) responds
        (not start or not door_closed and not clear);
    r8 = after (pre mode == SUSPENDED) :: (mode == COOKING) responds (start and door_closed and not clear);
    r9 = after (pre mode == SUSPENDED) :: (mode == SETUP) responds clear;

    r10 = global :: always (output == modelogic_output_type {mode = mode, seconds_remaining = seconds_remaining});

Properties:
    p1 = while (mode == COOKING) :: always door_closed;
    p2 = before start :: always (mode == SETUP);
    p3 = while ((mode == COOKING) or (mode == SUSPENDED)) :: always (seconds_remaining <= pre seconds_remaining);
    p4 = global :: always (mode <> COOKING);
```



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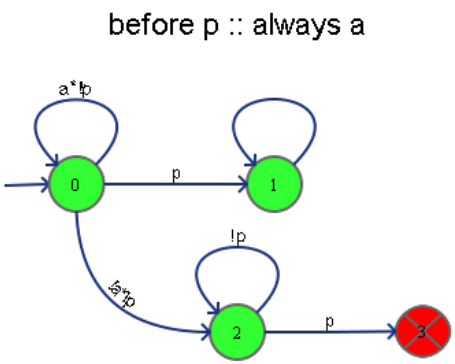
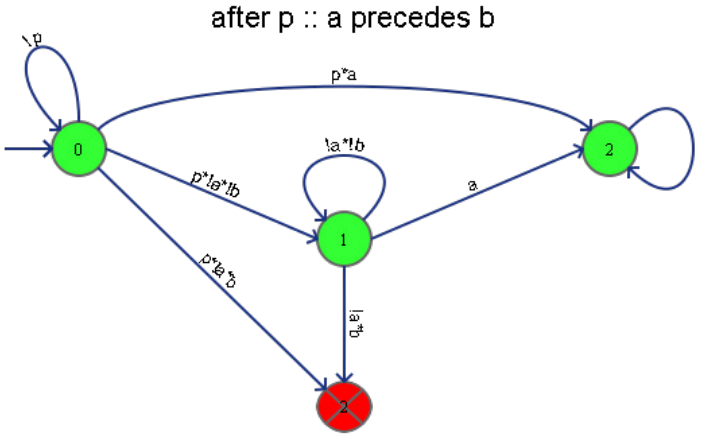
# Representing the Patterns in Lustre for Analysis

Each property is translated into a finite state machine. The green states denote accepting states, the red states failed states, and the grey states are non-accepting.



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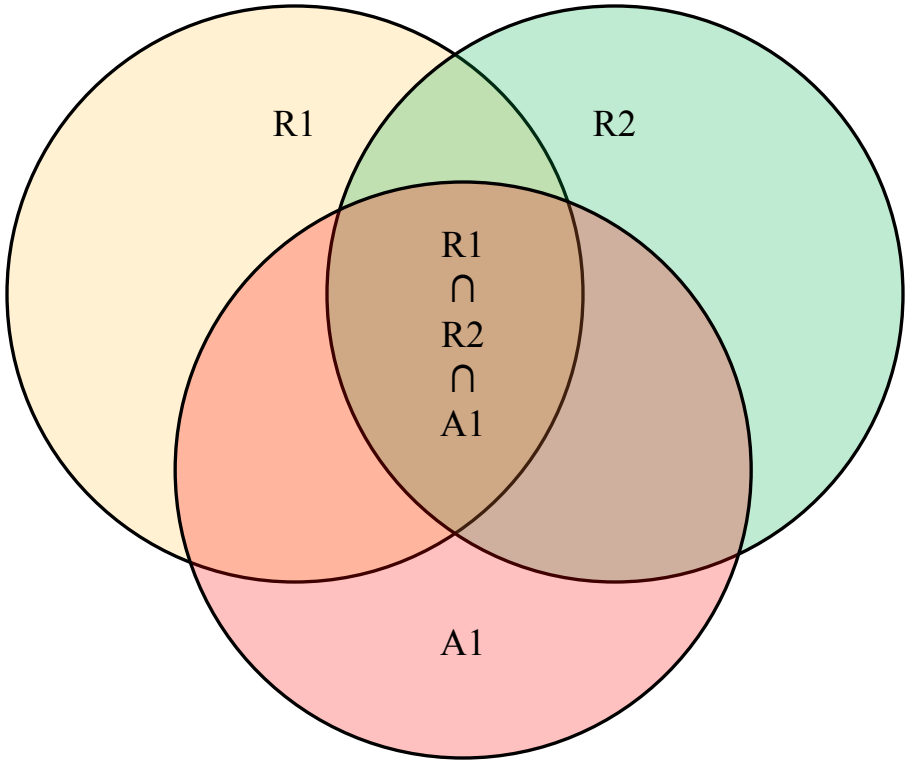
# Analysis in SpeAR

The intersection of the set of traces that our requirements accept defines the set of traces our system accepts. If a property P also accepts that set of traces, the system satisfies the property.




If a property P also accepts that set of traces our system satisfies that property.



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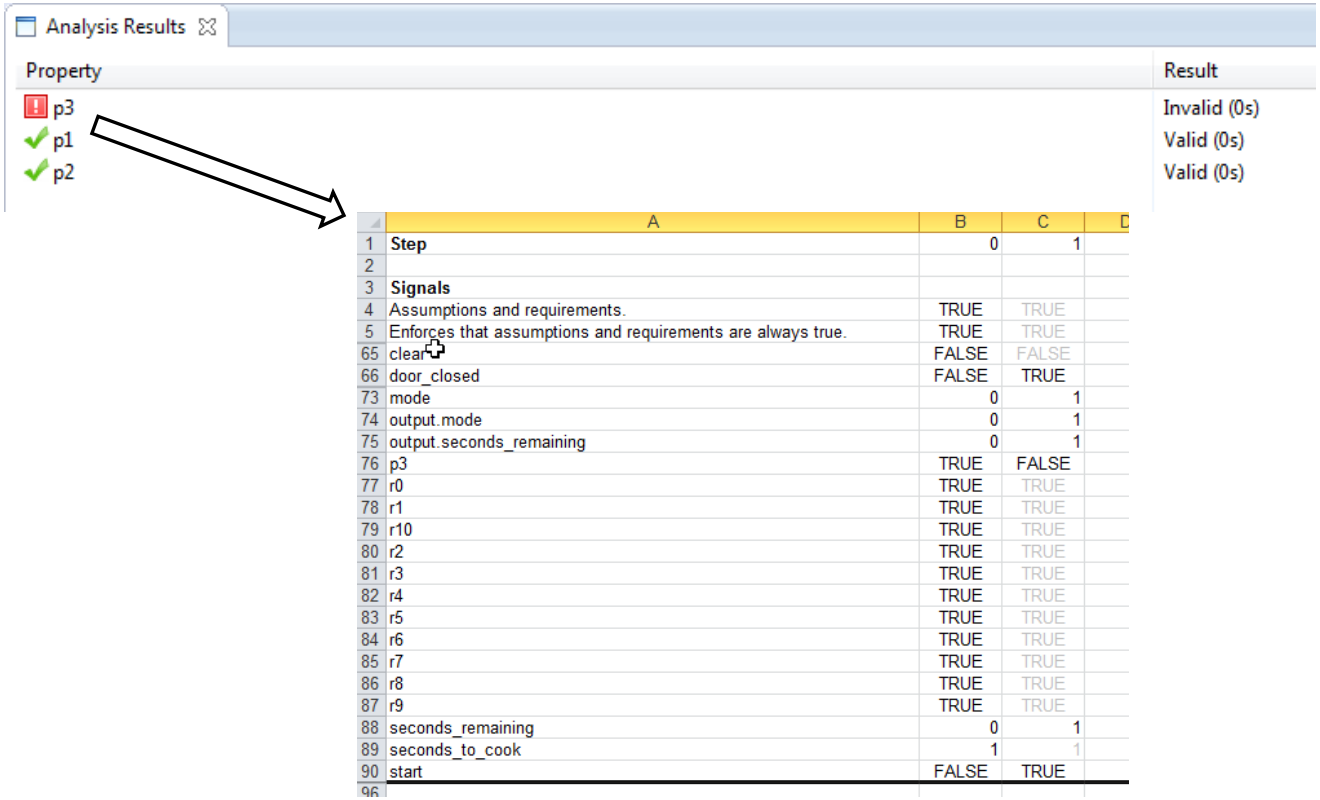
# Counterexamples

Analysis results are provided to the user in a graphical interface. If a property is violated by the requirements a trace is provided to the user for debugging.




| | A | B | C | D |
|---|---|---|---|---|
| 1 | **Step** | 0 | 1 | |
| 2 | | | | |
| 3 | **Signals** | | | |
| 4 | Assumptions and requirements. | TRUE | TRUE | |
| 5 | Enforces that assumptions and requirements are always true. | TRUE | TRUE | |
| 65 | clear | FALSE | FALSE | |
| 66 | door_closed | FALSE | TRUE | |
| 73 | mode | 0 | 1 | |
| 74 | output.mode | 0 | 1 | |
| 75 | output.seconds_remaining | 0 | 1 | |
| 76 | p3 | TRUE | FALSE | |
| 77 | r0 | TRUE | TRUE | |
| 78 | r1 | TRUE | TRUE | |
| 79 | r10 | TRUE | TRUE | |
| 80 | r2 | TRUE | TRUE | |
| 81 | r3 | TRUE | TRUE | |
| 82 | r4 | TRUE | TRUE | |
| 83 | r5 | TRUE | TRUE | |
| 84 | r6 | TRUE | TRUE | |
| 85 | r7 | TRUE | TRUE | |
| 86 | r8 | TRUE | TRUE | |
| 87 | r9 | TRUE | TRUE | |
| 88 | seconds_remaining | 0 | 1 | |
| 89 | seconds_to_cook | 1 | 1 | |
| 90 | start | FALSE | TRUE | |
| 96 | | | | |



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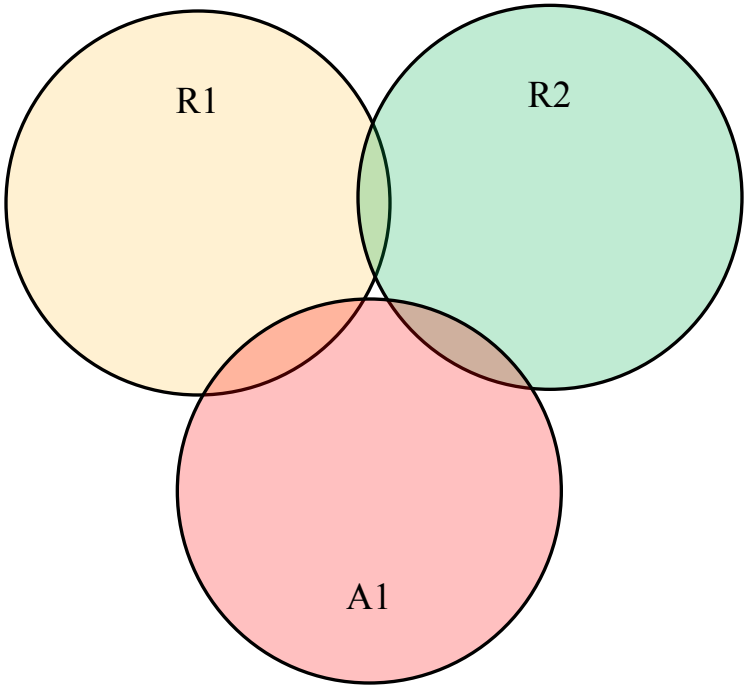
# Realizability

If there is no set of traces that satisfy the intersection of the requirements set, the set is not realizable. SpeAR (in-progress) will be able to identify unrealizable specifications.




If there is no set of traces that all the requirements and assumptions accept, the system is not realizable.



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## Download Spear, it's open source!

http://www.github.com/afifarek/spear

Check out the releases tab, or build from source using Eclipse.

## Questions?