



# Goal-Directed Context Validation for Adaptive Ubiquitous Systems

**SEAMS 2007**

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# Outline

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- Background
- Goal-Directed Context Validation
- Evaluation
- Conclusion

# Context

- E.g., my location, this room's temperature, Hilton's 2/f network condition, ...
- Characterize a program's environment
- Useful for programs to adapt their behaviors
- Programs generate contexts too.
  - Is the room quiet or noisy?
  - Which room? Nicollet? Symphony II? Symphony III?
  - I am in the Nicollet room and this room right now!

Am I a phantom? Faulty program? Wrong contexts?

# Noisy Context

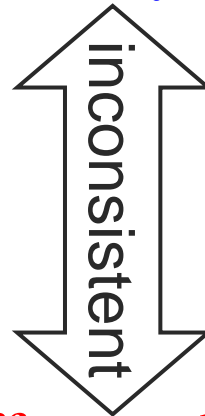
- Perfect environment + poor sensor  $\Rightarrow$  noisy contexts
- Interfering environmental conditions  $\Rightarrow$  noisy contexts
- Imperfect modeling of environments  $\Rightarrow$  noisy contexts
- ...

Find a precise oracle to validate contexts?  
More than the ideal?

# Context Validation

- Model context relationships as constraints
- Check contexts against constraints to find *inconsistency*

I am in the Nicollet room and Symphony II room right now!

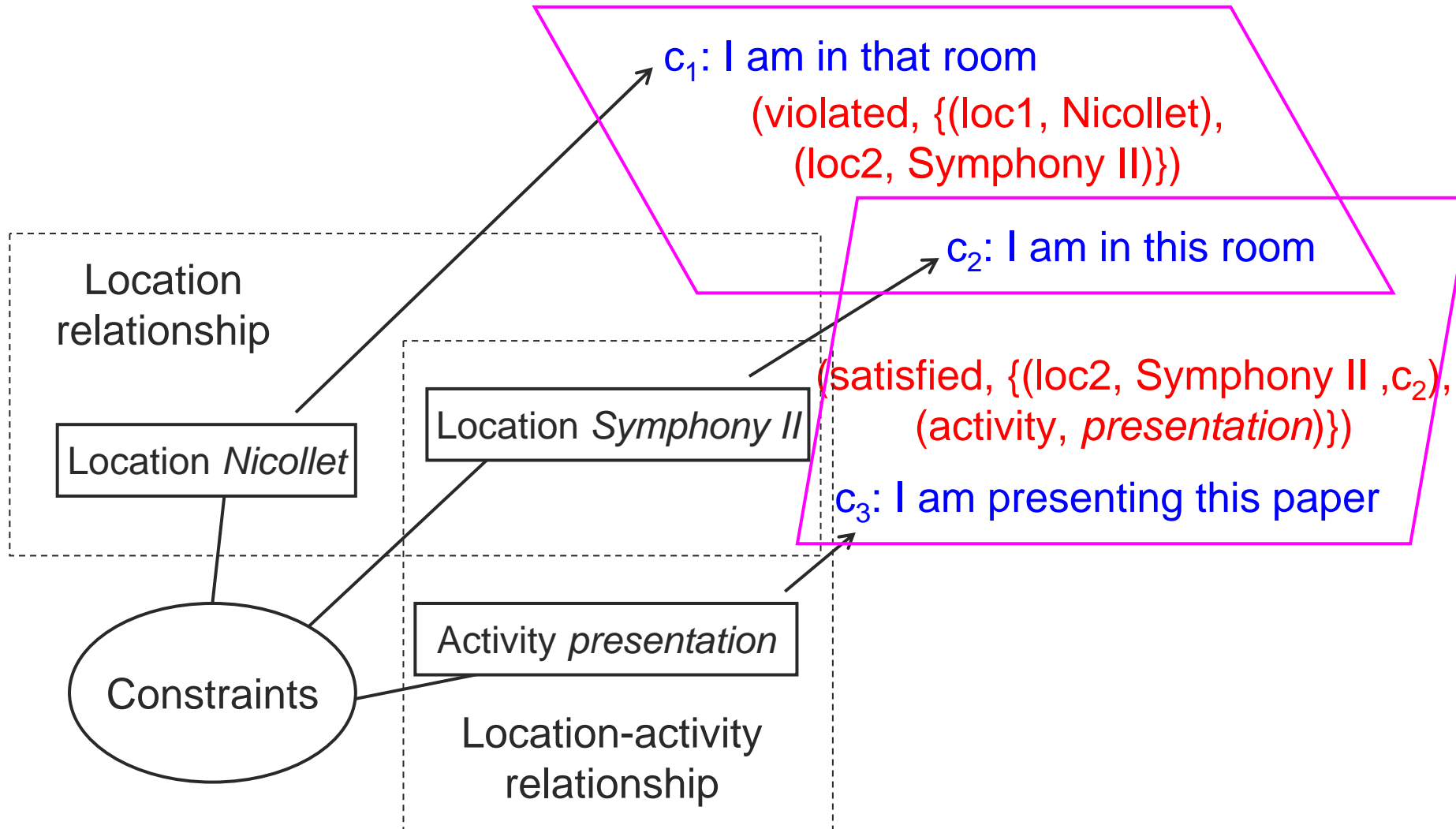


Constraint:

“nobody can be in two different places at the same time”

See our previous work in FSE'05 and ICSE'06

# Link: Tell how contexts work with a constraint

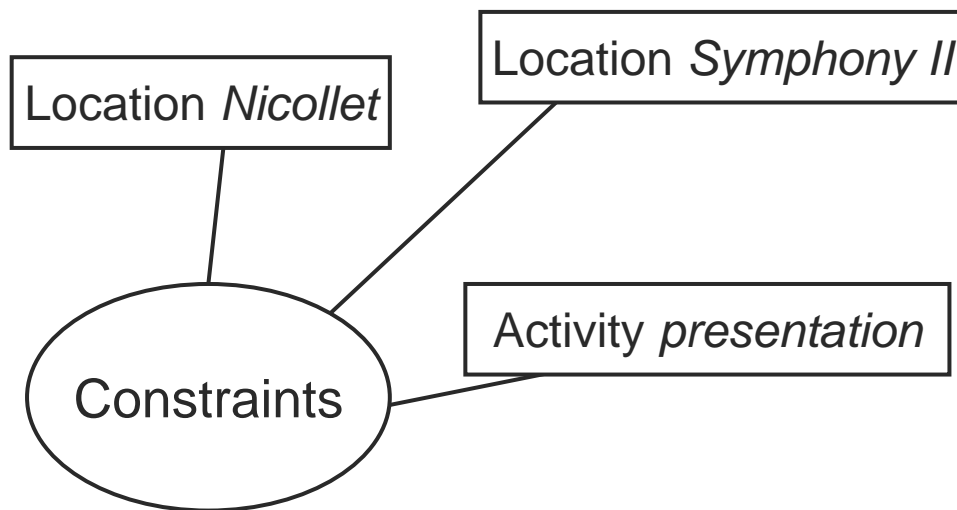


# Link

Links: **show why inconsistency occurs**

(violated, {(loc1, Nicollet), (loc2, Symphony II)})

(satisfied, {(loc2, Symphony II), (activity, *presentation*)})



Useful for context resolution

# Link: Tell how contexts fails a constraint

Links: **show why inconsistency occurs**

(violated, {(loc1, Nicollet), (loc2, Symphony II)})

(satisfied, {(loc2, Symphony II), (activity, *presentation*)})

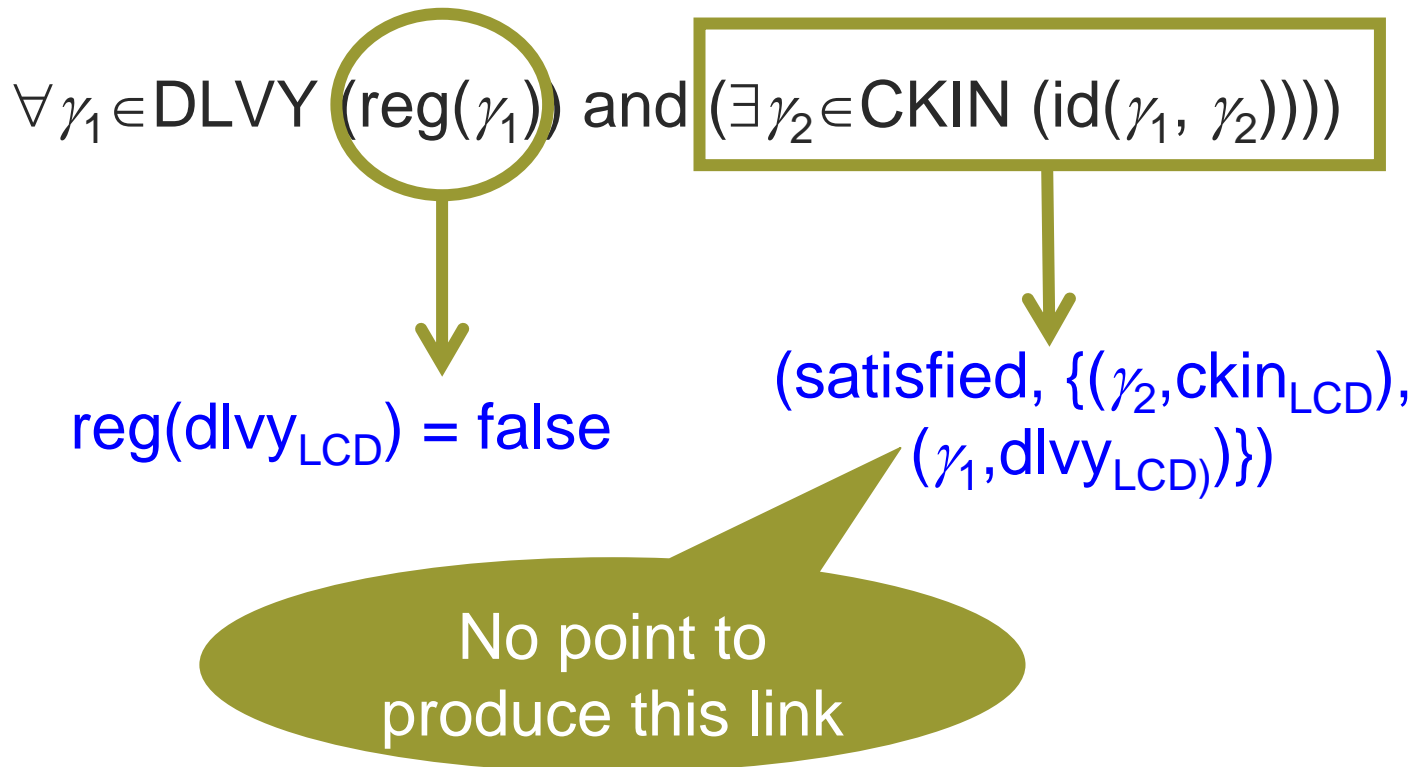
Some resolution choices:

- Delete Nicollet
- Delete Symphony II



# Some links are not useful

- Warehouse management
  - Any RFID-tagged LCD monitor should be sensed as *registered* and *checked in* before delivery.



# Redundant Links

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- How does it happen?
  - Intermediate links are generated but not used
- Occur frequently when specifying constraints
  - An initial study of 30 postgraduate students at 2 Univ.
    - Over 42% of the specified constraints suffer from this problem
    - Over 75% of the generated links are not used at the end
- We want to improve the situation

# Related Work

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- Frameworks and middleware infrastructures for ubiquitous computing
  - Context Toolkit, ActiveCampus, EgoSpaces, Lime, Gaia, RCSM, ...
  
- Context validation
  - Consistency management
    - For application profiles [TSE'03] , triggered actions [TKDE'03], data structures [ICSE'05], XML documents [TOSEM'03], UML models [ICSE'06]
  - Our previous work: Cabot [FSE'05, ICSE'06]
    - Inconsistency resolution with policies
    - Incremental context validation
  
- Testing
  - Our previous work [FSE'06]

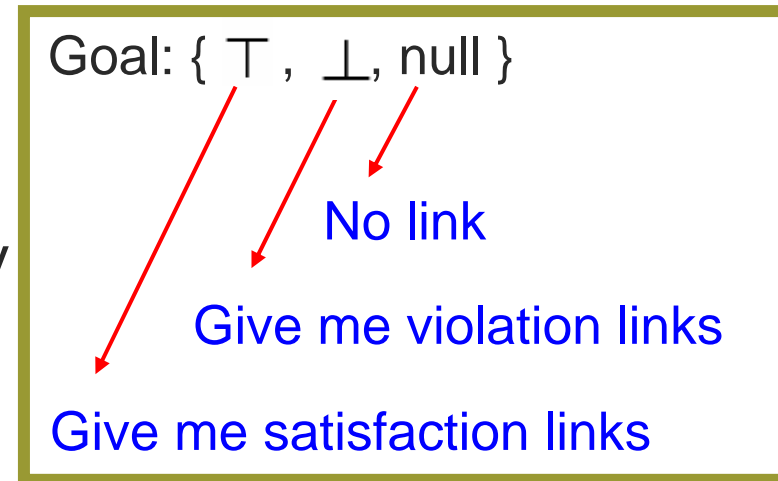
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- Introduction
- **Goal-Directed Context Validation**
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# Goal-Directed Context Validation

- Three steps
  - (1) Accept a user goal
  - (2) Decide sub-goals recursively
  - (3) Bottom-up link generation



$$\forall \gamma_1 \in \text{DLVY} (\text{reg}(\gamma_1)) \text{ and } (\exists \gamma_2 \in \text{CKIN} (\text{id}(\gamma_1, \gamma_2)))$$

Goal =  $\perp$

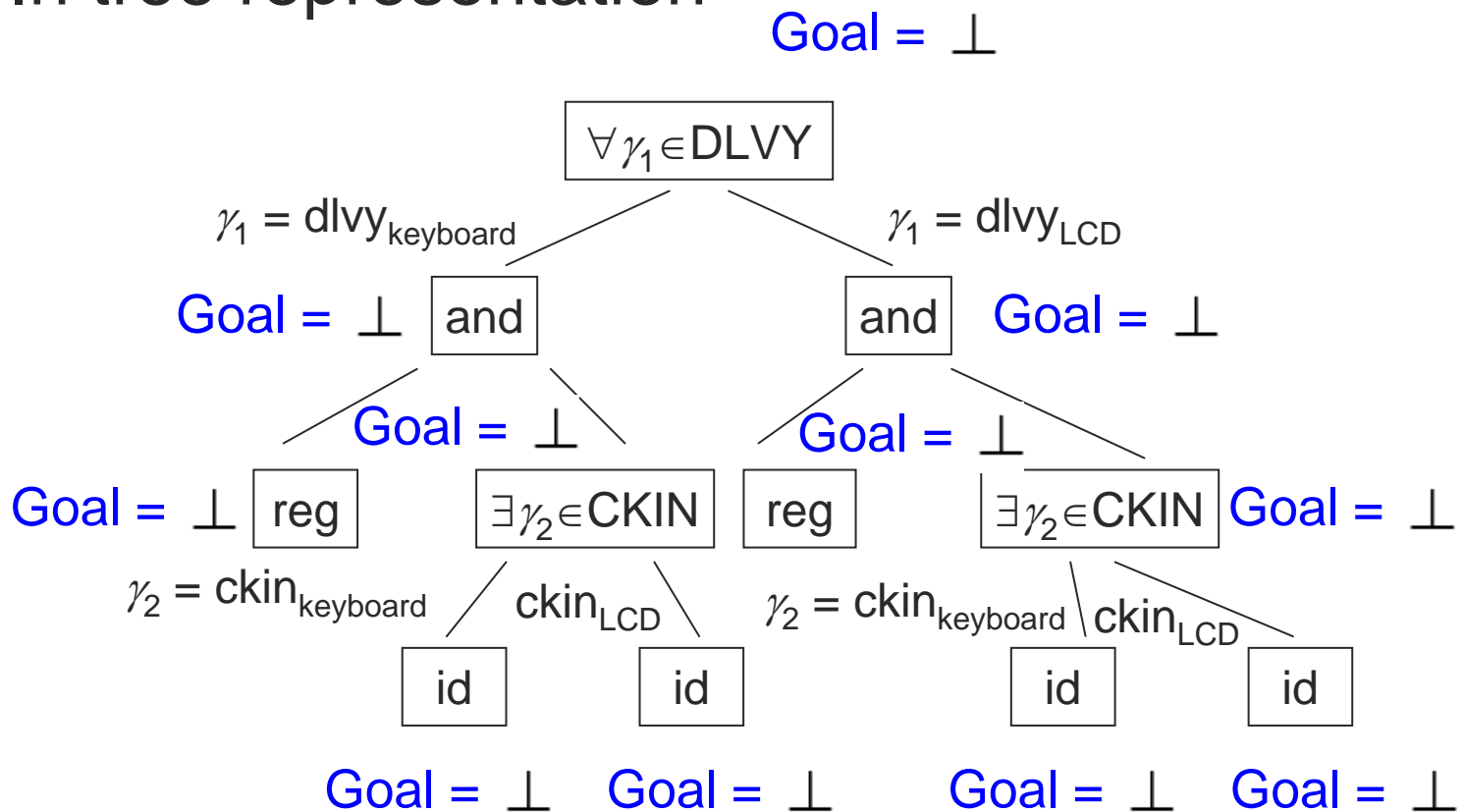
Goal =  $\perp$

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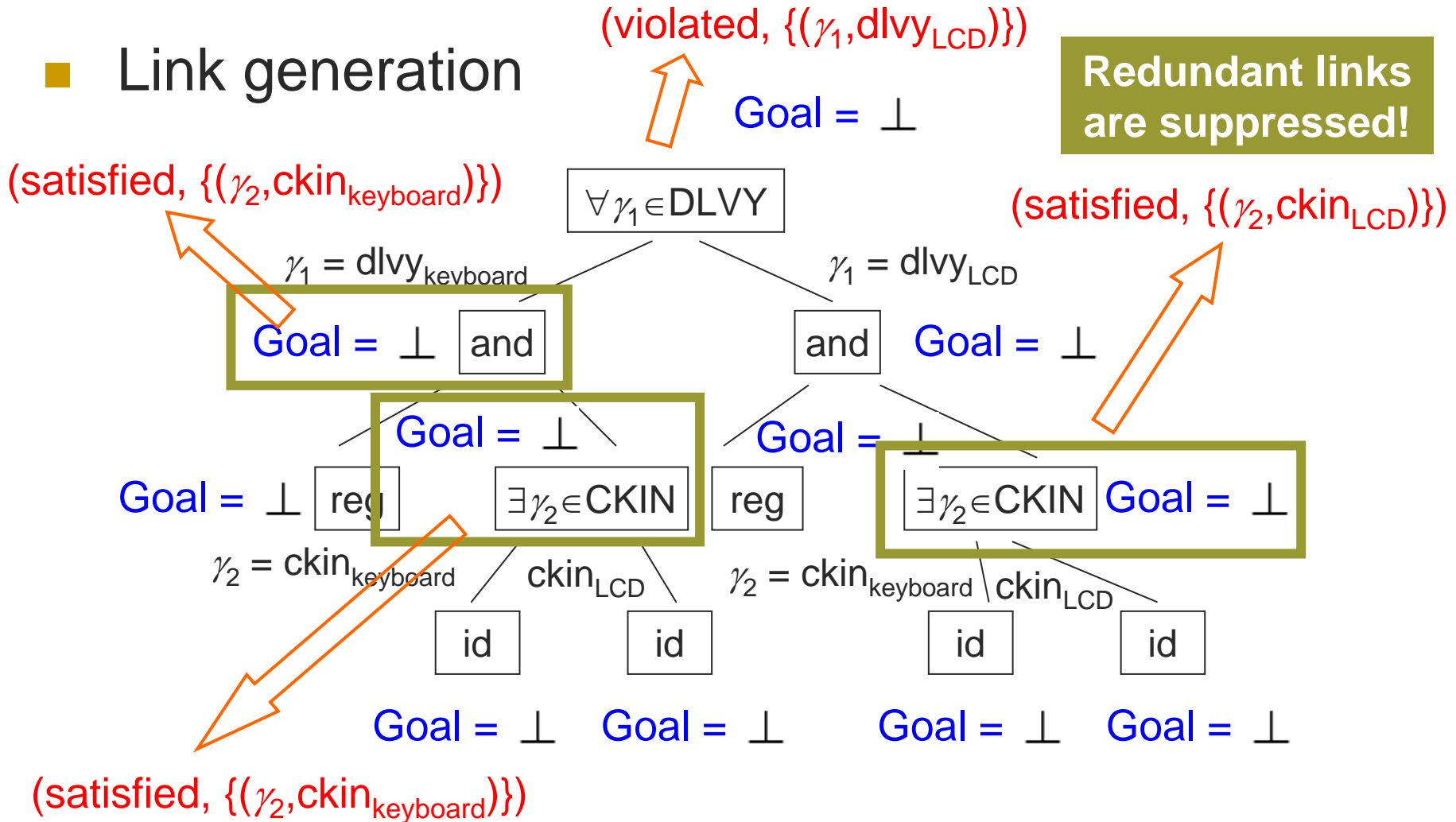
# Goal-Directed Context Validation

- In tree representation



# Goal-Directed Context Validation

## ■ Link generation



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# Properties

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- Completeness and Soundness ✓
  - It will not suppress any links that meet your goal, and no invalid links.
- Conciseness ?
  - Partial

# Conciseness Analysis

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## Two metrics

- Used link ratio (U-LR)
  - How well the sub-formula constitute to the final link
- Effective link ratio (E-LR)
  - How well the generated links contribute to the final link
- Assumptions
  - Uniform distributions of goal, possible evaluation results

# Conciseness Analysis

	U-LR (%)		E-LR (%)	
	Ours	Previous Work	Ours	Previous Work
$\forall \gamma \in S (f)$	100	50	100	33.3
$\exists \gamma \in S (f)$	100	50	100	33.3
$(f)$ and $(f)$	83.3	75	100	33.3
$(f)$ or $(f)$	83.3	75	100	33.3
$(f)$ implies $(f)$	83.3	75	100	33.3
not $(f)$	100	100	100	33.3

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# Conclusion and Future Work

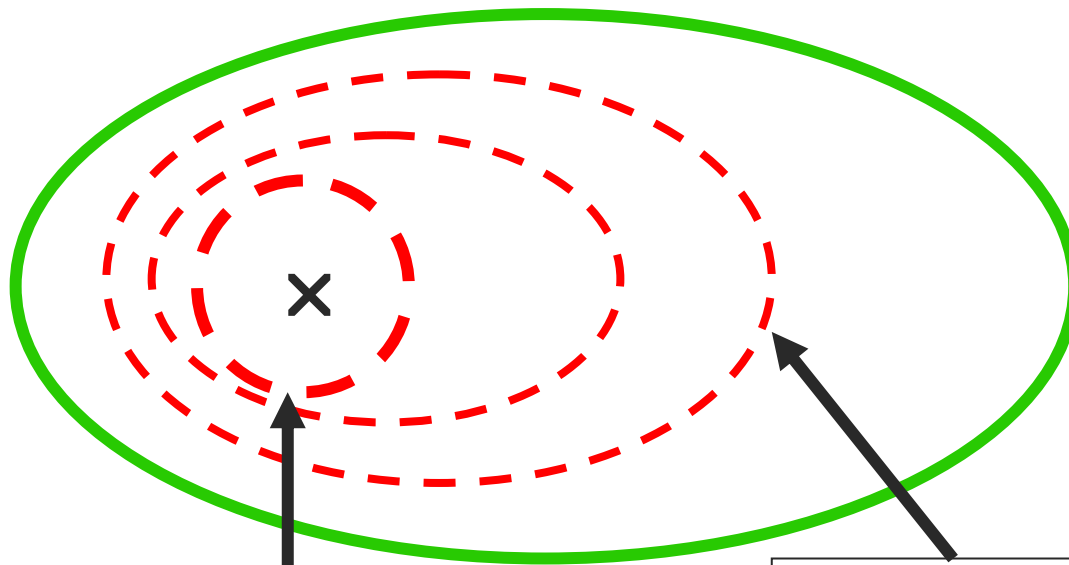
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- Addressed one of the most time-consuming parts in context validation
  - Proposed a refined model for link generation that suppress redundant links
  
- Future Work
  - Universal formula generates violation links only
    - Need to add timing (?) to constraints to bound the context queues
    - Necessary?

# Future Work



A family of constraints, forming a subsumption hierarchy



Can't do it efficiently when there are many junk links

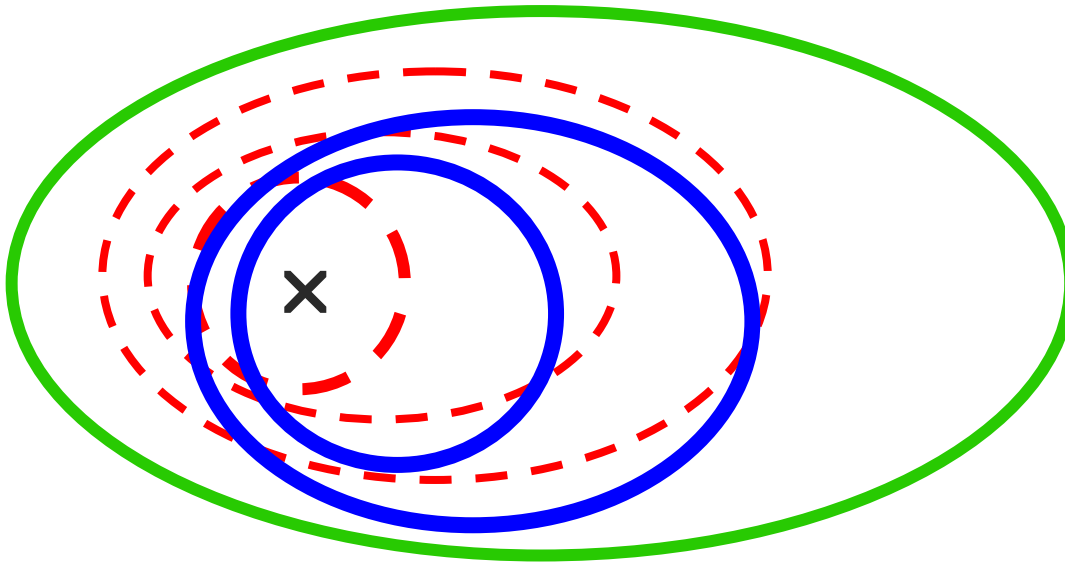
**From specific**

**To improve the level of abstraction to explain a violation**

# Future Work



May switch between families of constraints  
- Adapt to different consistency levels



# Questions and Comments?

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Thank you.