Goal-Directed Context Validation for Adaptive Ubiquitous Systems

SEAMS 2007

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Outline

- 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

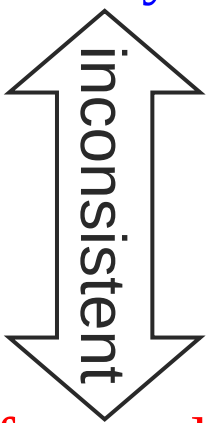
- Perfect environment + poor sensor $\Rightarrow$ noisy contexts
- Interfering environmental conditions $\Rightarrow$ noisy contexts
- Imperfect modeling of environments $\Rightarrow$ noisy contexts
- …

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!

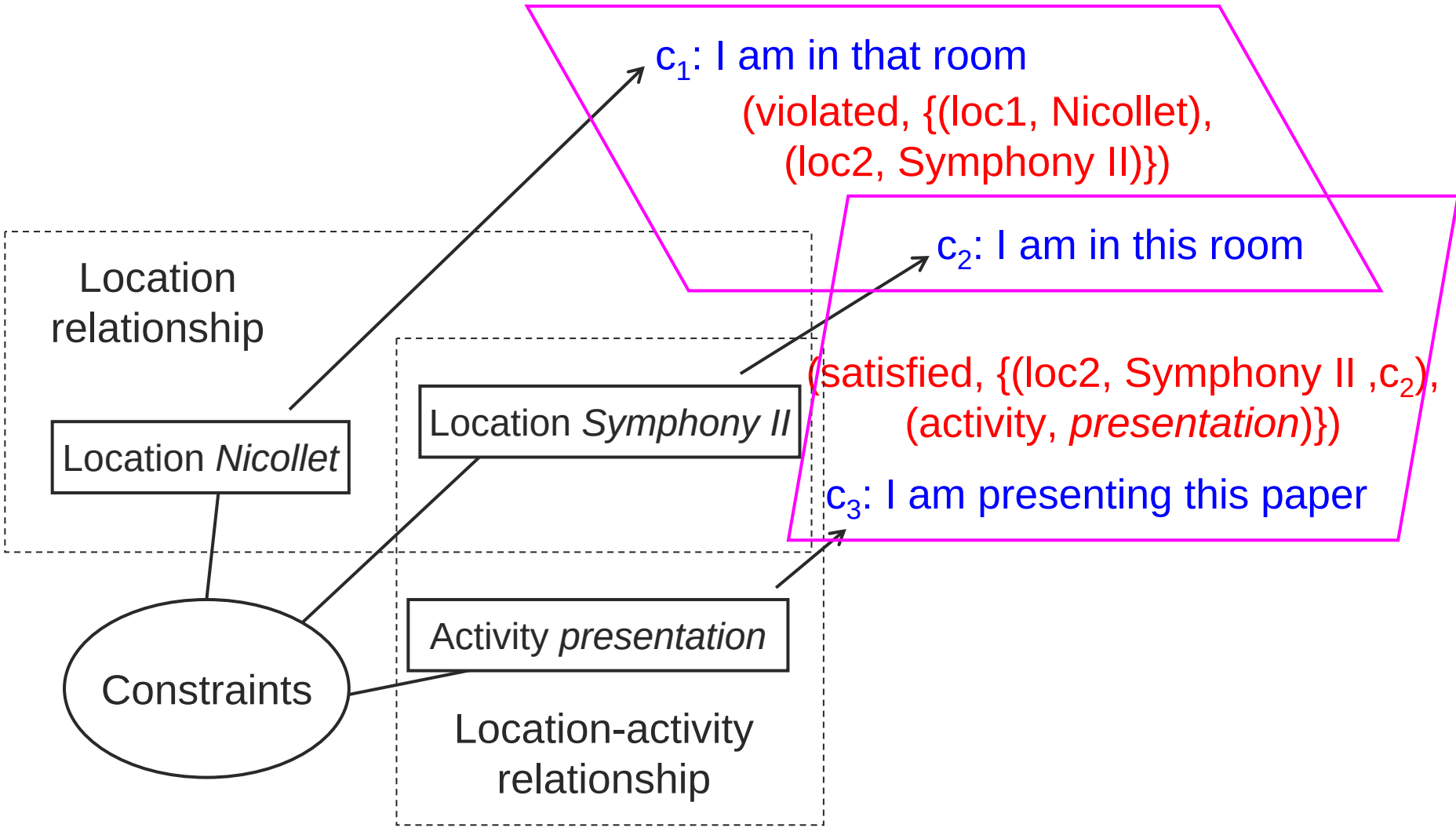


Constraint:

"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

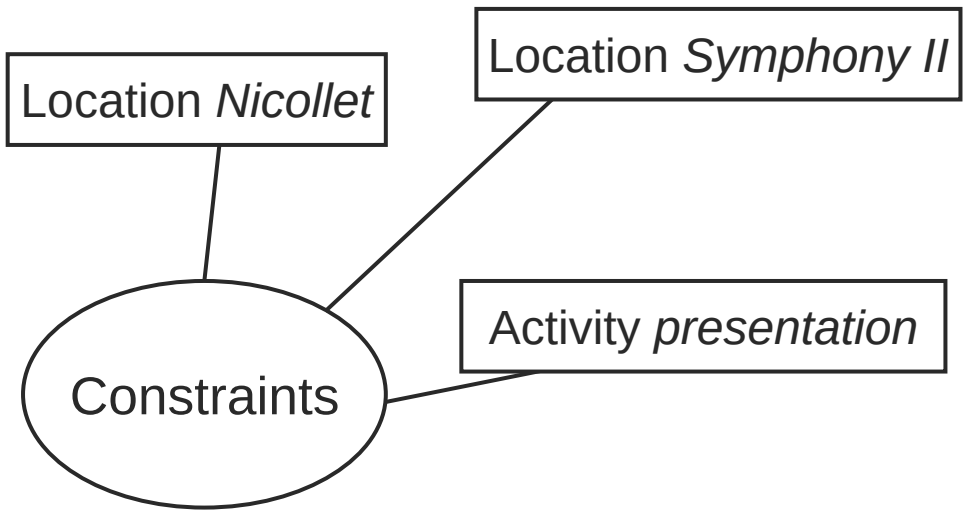


Link

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)})

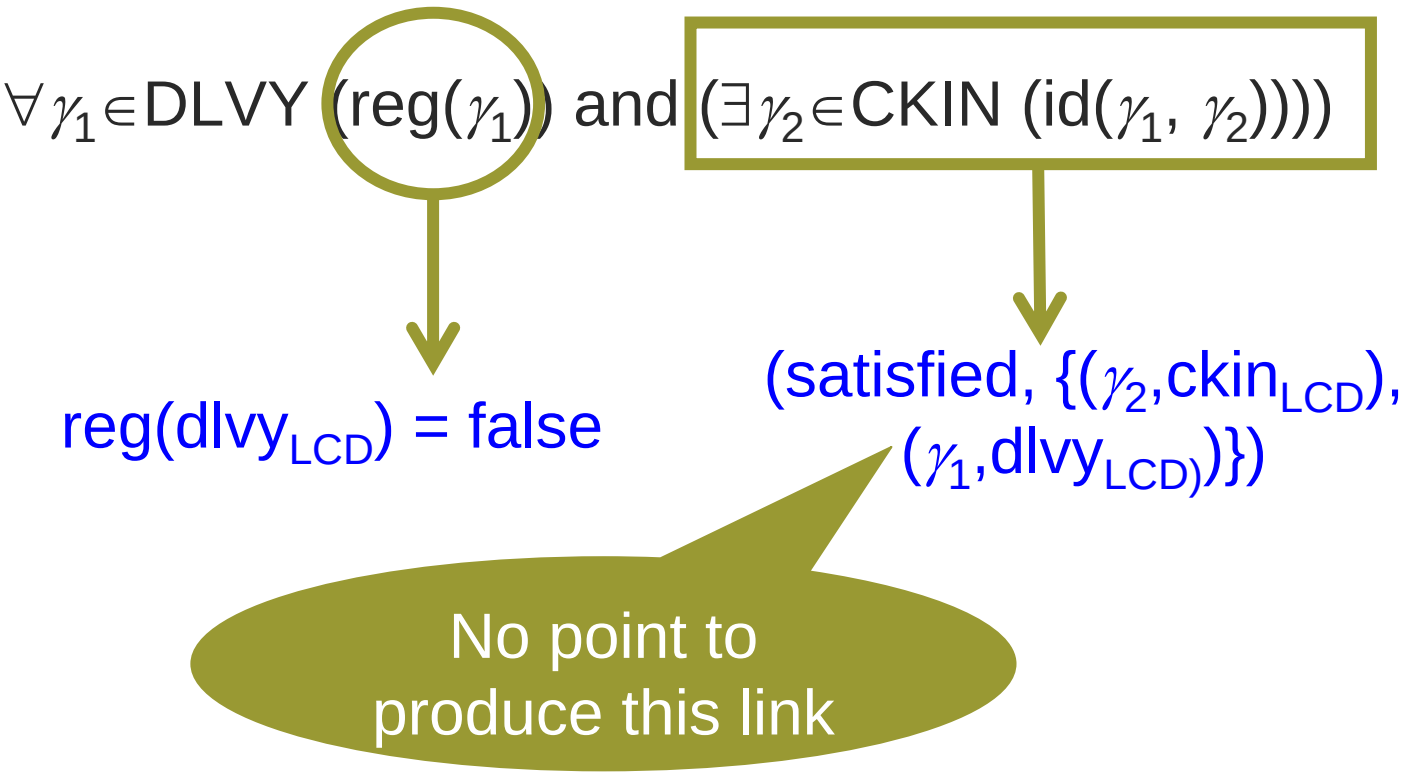
(satisfied, {(loc2, Symphony II), (activity, *presentation)*})

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

- 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

- 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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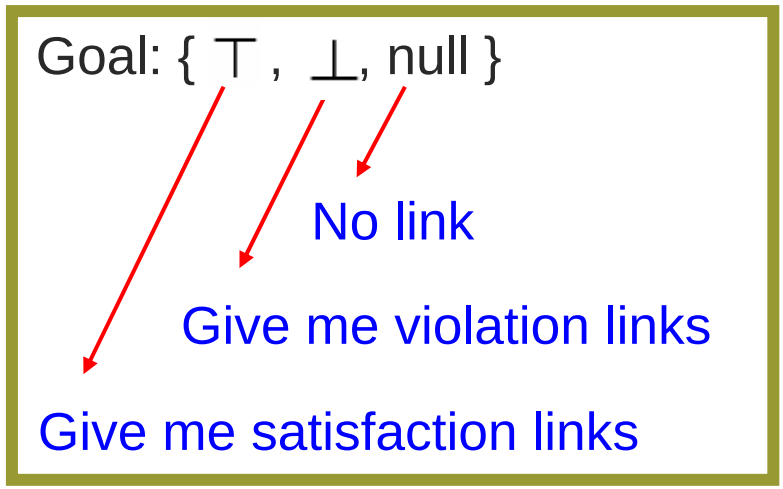
Goal-Directed Context Validation

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



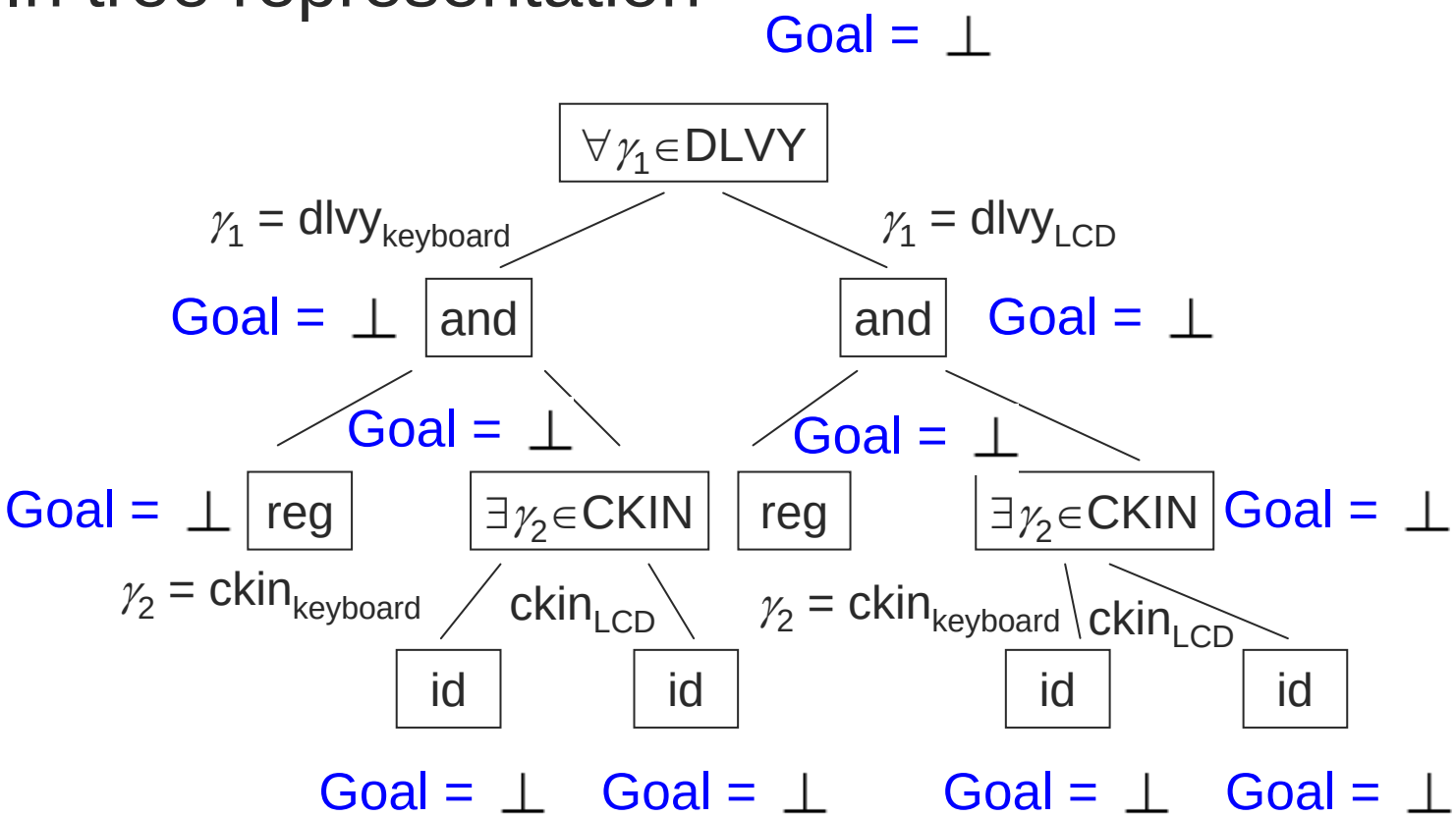
$\forall \gamma_1 \in$ DLVY (reg(γ_1)) and ($\exists \gamma_2 \in$ CKIN (id(γ_1, γ_2)))

Goal = ⊥ Goal = ⊥

Goal = ⊥ Goal = ⊥

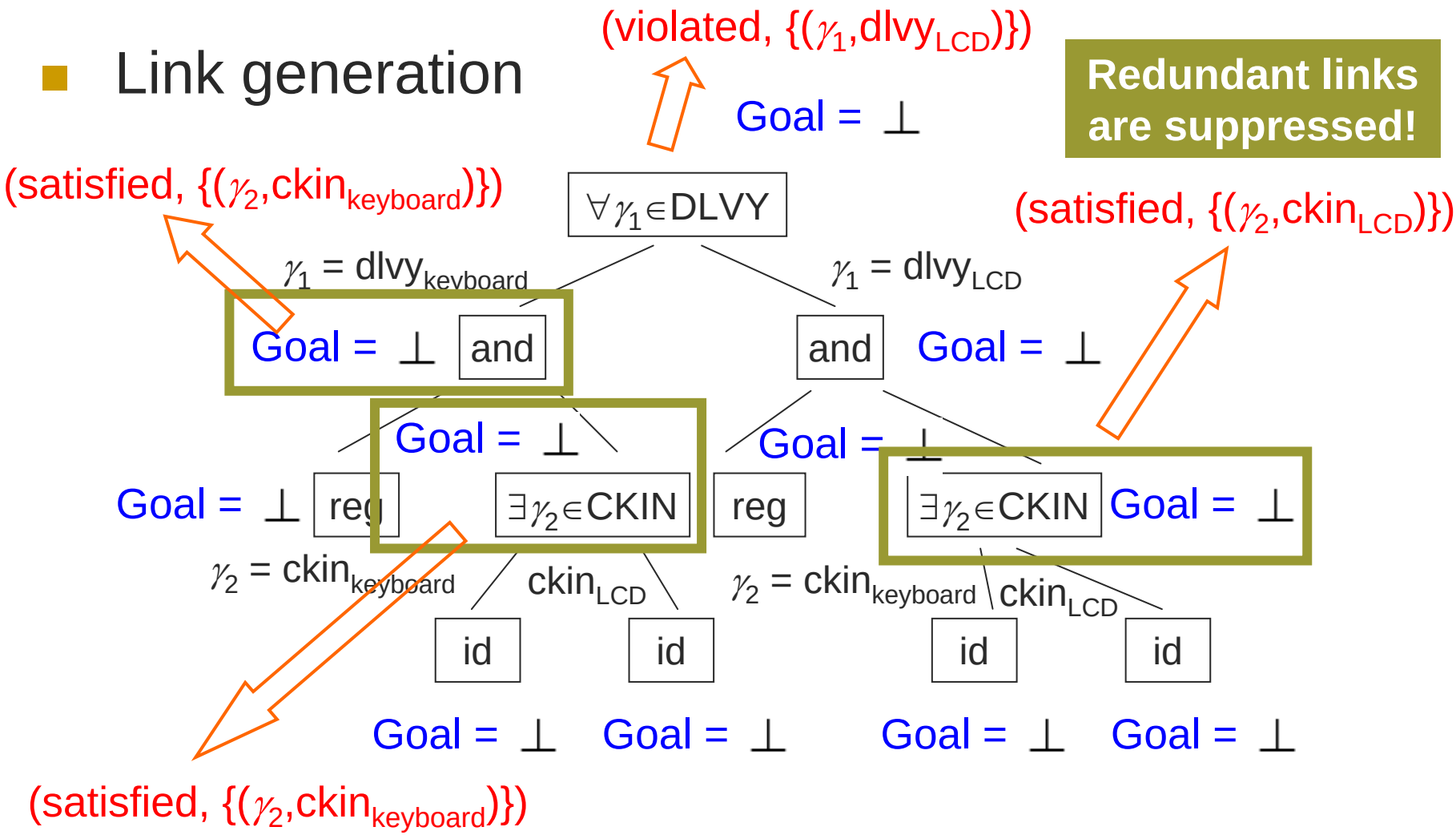
Goal-Directed Context Validation

- In tree representation



Goal-Directed Context Validation

- Link generation



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Properties

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

Conciseness Analysis

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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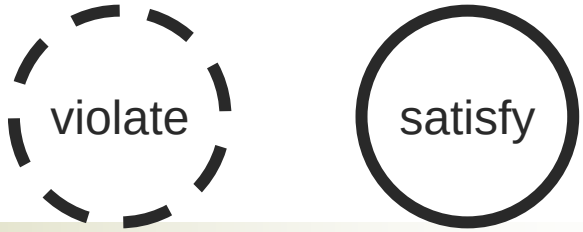
Conclusion and Future Work

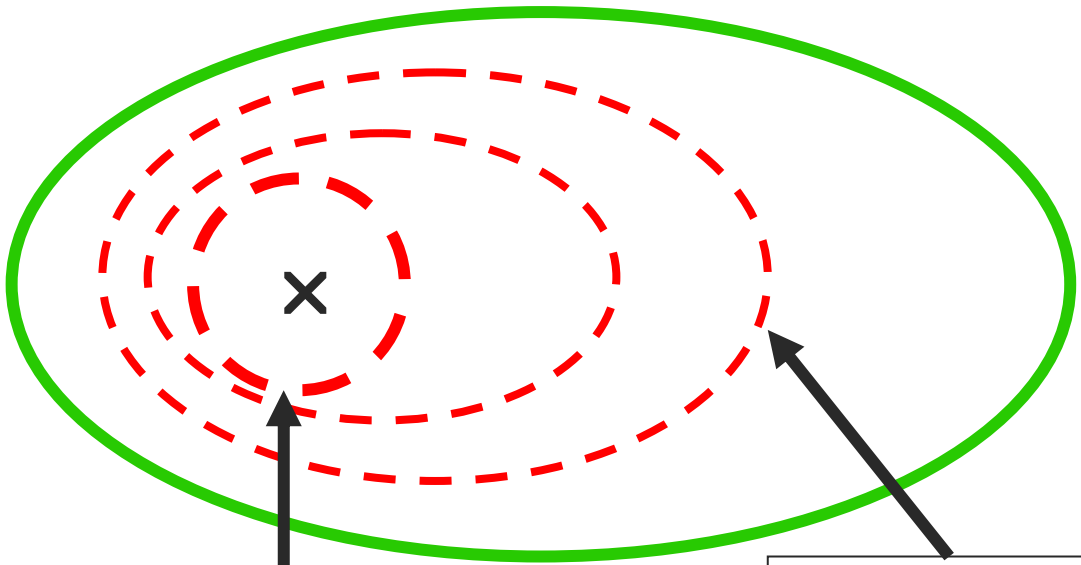
- Addressed one of the most time-consuming parts in context validation
  - Proposed a refined model for link generation that suppress redundant links

- 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

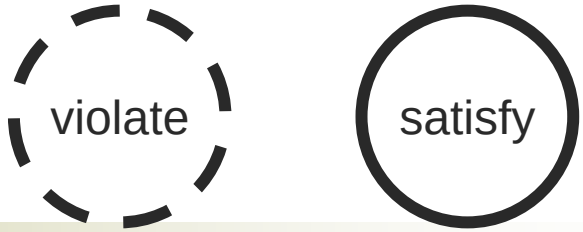


Can’t do it efficiently when there are many junk links

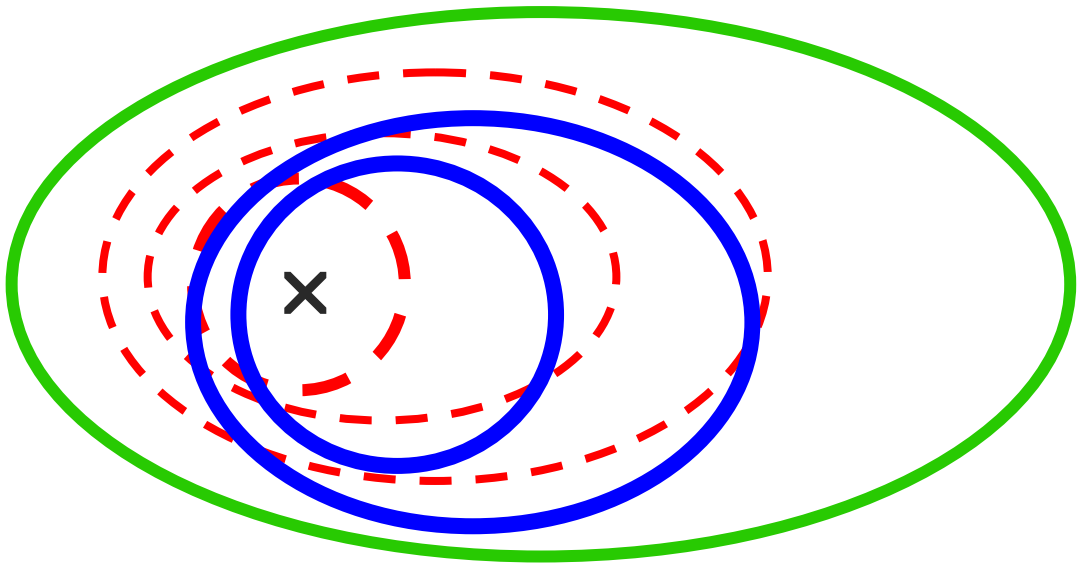
From specific

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?

Thank you.