Goal-centric traceability for managing Non-Functional Requirements

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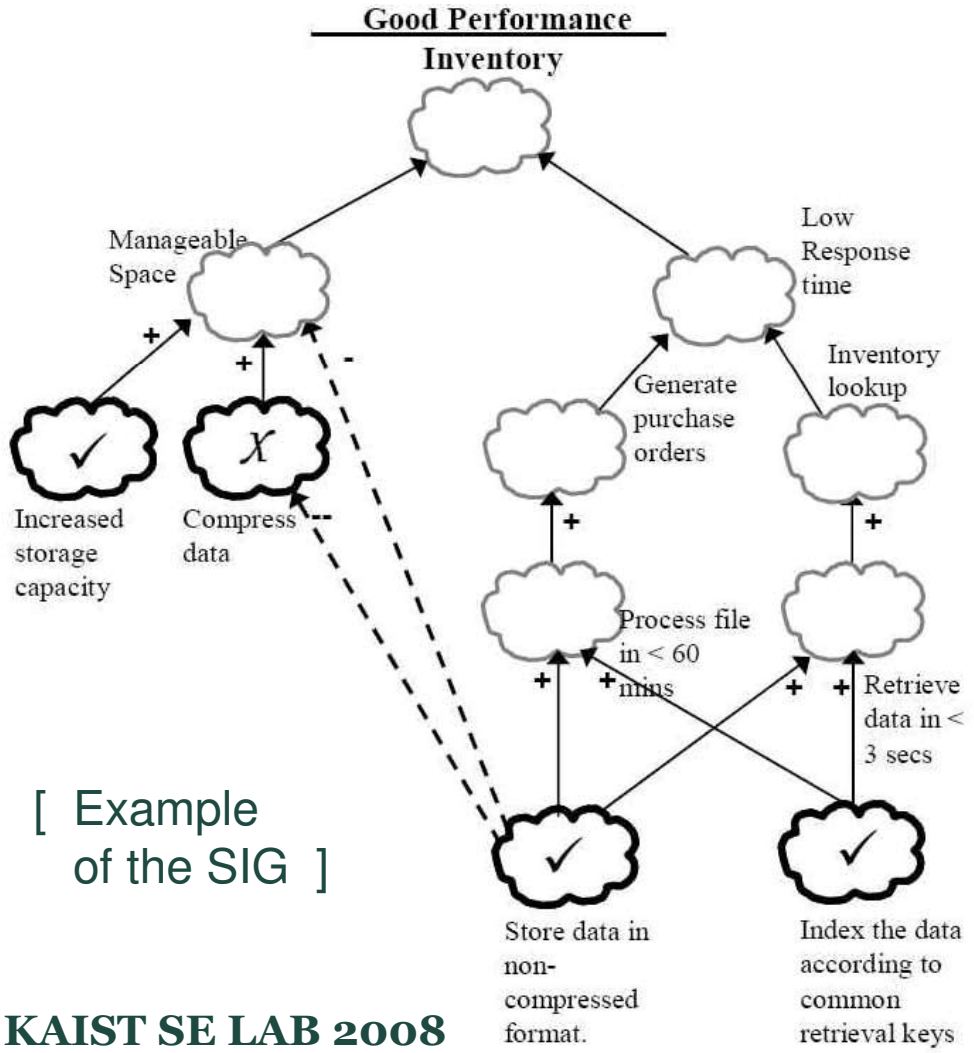
Introduction

- Motivation
  - NFRs are important, but not considered well
    - Due to difficulties in tracing interdependencies
    - Due to difficulties in determining tradeoffs
- Research goal
  - Introduce GCT approach to managing NFRs
    - Represent it with SIG*
    - Grasp impacts
      - When changes to functional requirements are occurred

*SIG = Softgoal Interdependency Graph

Background(1/2)

- Softgoal Interdependency Graph(SIG)



[Example of the SIG]

: Goal or subgoal

: Operationalization

✓ : Satisficed goal or OP.

X : Non-satisficed goal or OP.

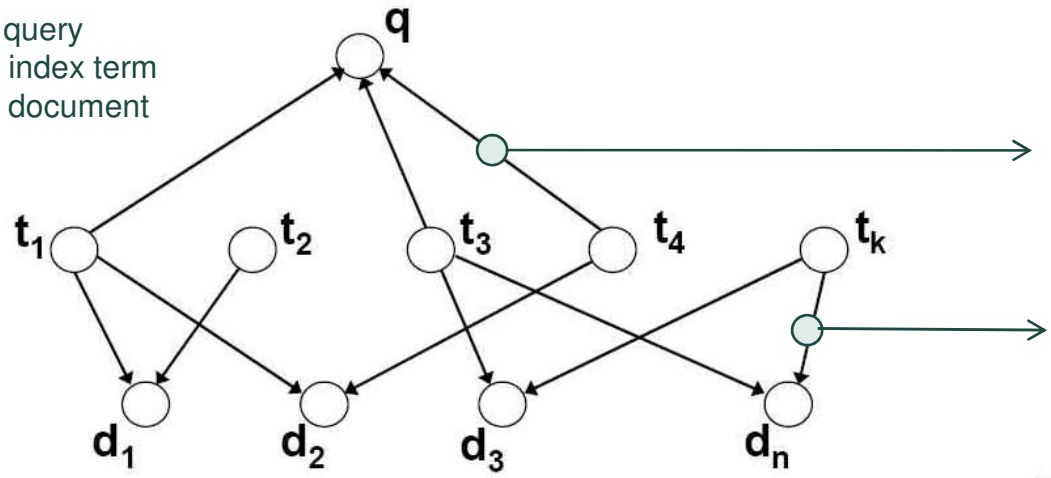
++ : makes
\+ : helps
\- : hurts
-- : breaks
? : unknown

Background(2/2)

- Probabilistic network model
  - One of Information Retrieval(IR) techniques

Model assumption
- Relevance relationship between a document and a user's query cannot be determined with certainty

q : query
t_i : index term
d_i : document



$$pr(q) = \sum_i pr(q \mid t_i) pr(t_i)$$

$$pr(d_j) = \sum_i pr(d_j \mid t_i) pr(t_i)$$

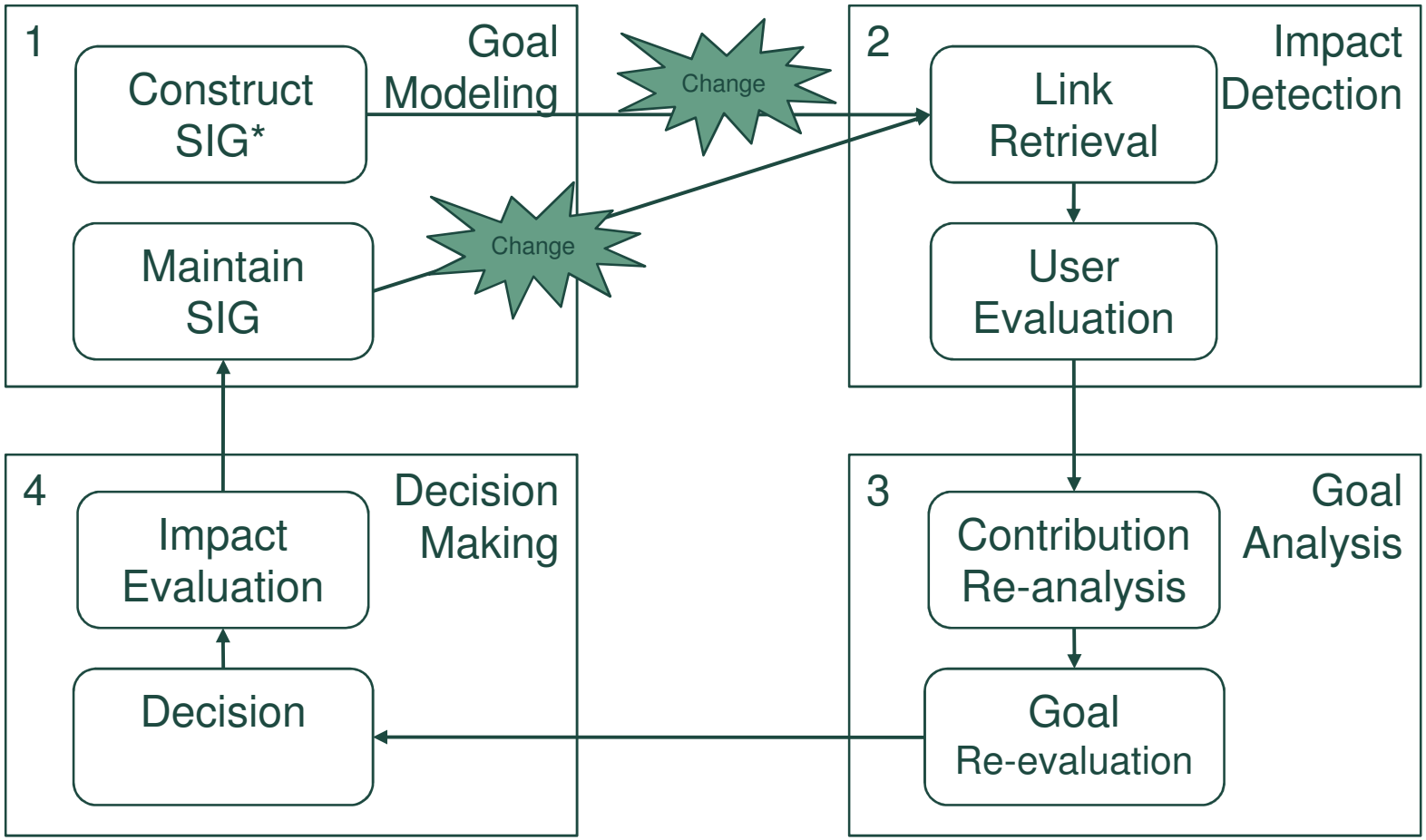
$$pr(d_j \mid t_i) = \frac{freq(d_j, t_i)}{\sum_k freq(d_j, t_k)}$$

[Example of a probabilistic network model]

Overall approach

- Goal-Centric Traceability(GCT)

SIG* → NFRs in SE, Kluwer Academic, 2000

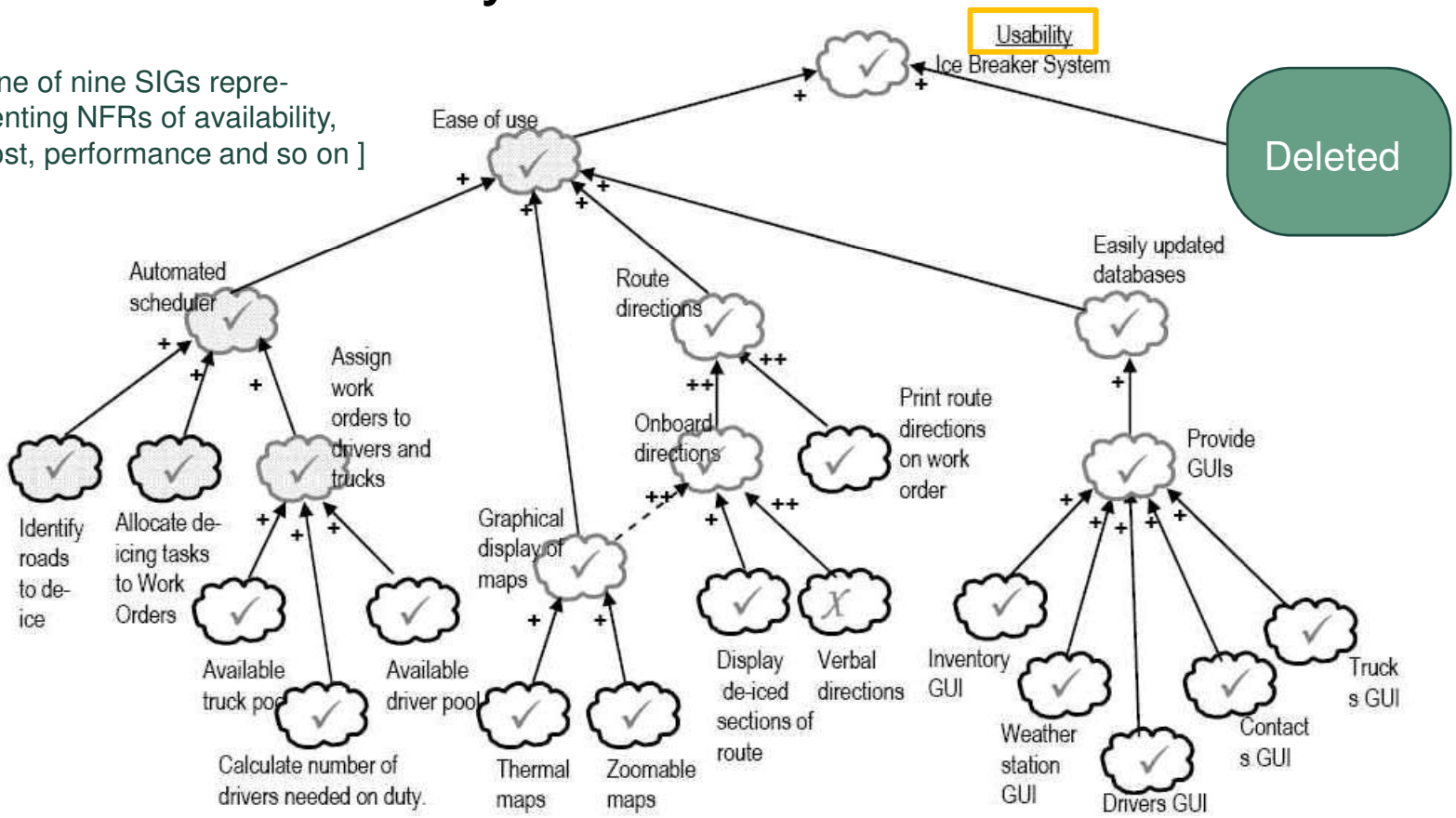


Goal modeling

Construct SIG

- Ice Breaker system

[One of nine SIGs repre-senting NFRs of availability, cost, performance and so on]



Impact detection(1/2)

- Link retrieval(with the tool)
  - Use of a probabilistic network model for runtime link gen.
    - between UML class & sequence diagram and NFRs
    - With the threshold satisfying

"maximize Recall + Precision, where recall > 85%".

(Training set was used to select the threshold values)

✓ $\text{Recall} = \frac{\text{Number of relevant documents retrieved}}{\text{Number of relevant documents}}$

✓ $\text{Precision} = \frac{\text{Number of relevant documents retrieved}}{\text{Total number of documents retrieved}}$

Impact detection(2/2)

- Experimental evaluation (to measure the effectiveness of the IR)

	Training Set						*Full data set*
Threshold	0.015	**0.02**	0.025	0.030	0.04	0.05	0.02
Actual	90	**90**	90	90	90	90	619
Retrieved	226	**205**	190	180	154	135	1052
Correctly retrieved	87	**86**	80	78	76	70	540
Recall	0.9667	**0.9556**	0.8889	0.8667	0.8444	0.7778	0.8724
Precision	0.3850	**0.4195**	0.4210	0.4333	0.4935	0.5185	0.5133
Objective Function (Recall + Precision)	1.3517	**1.3751**	1.3099	1.3000	Recall < 85%	Recall < 85%	

[Results with a general query]

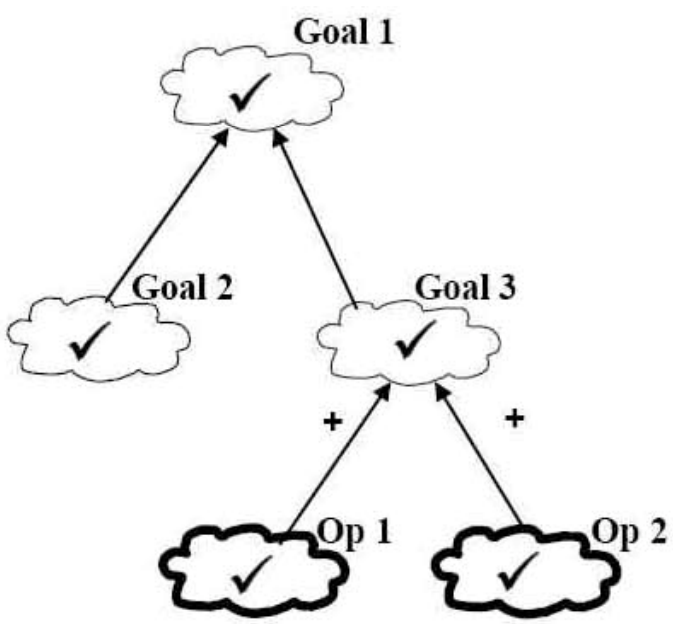
	Accuracy	*Availability*	*Completeness*	*Cost*	*Extensibility*	*Op. Security*	*Performance*	*Safety*	*Usability*
Actual	46	46	74	50	94	16	71	79	143
Recall	0.8478	0.5000	0.8514	0.9400	0.9468	0.8750	0.9014	0.8608	0.9301
Precision	0.4063	0.4107	0.5122	0.8103	0.5528	0.5000	0.4156	0.4626	0.5833

[Results with a SIG type query]

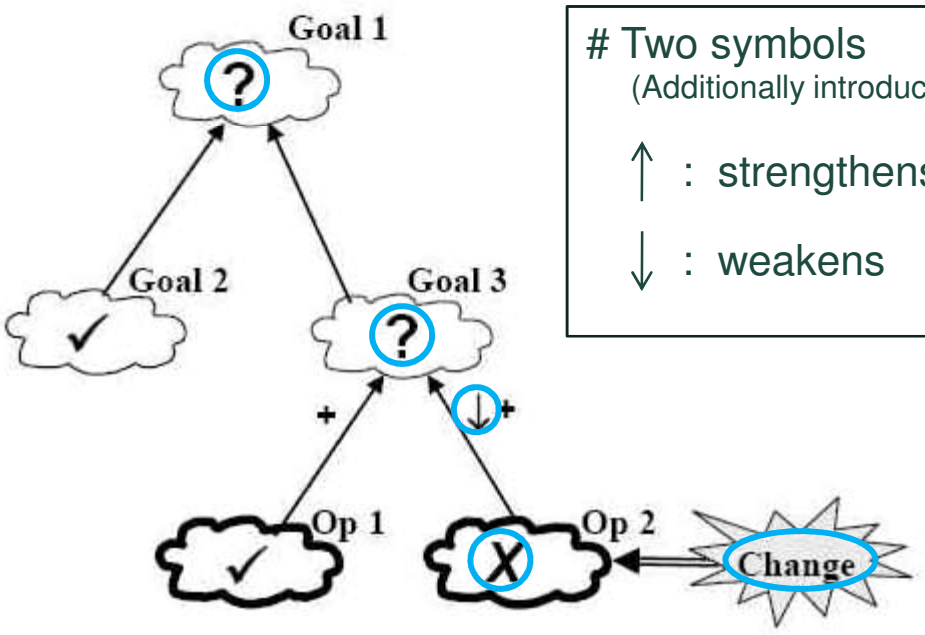
- About 14 returned-links related to each query
- About 50% links were discarded by a user

Goal analysis

- Goal re-evaluation
  - Determine if the goal can be fulfilled
    - By operationalizations after changes



[SIG prior to change]



[SIG showing change impact]

Two symbols
(Additionally introduced)

↑ : strengthens

↓ : weakens

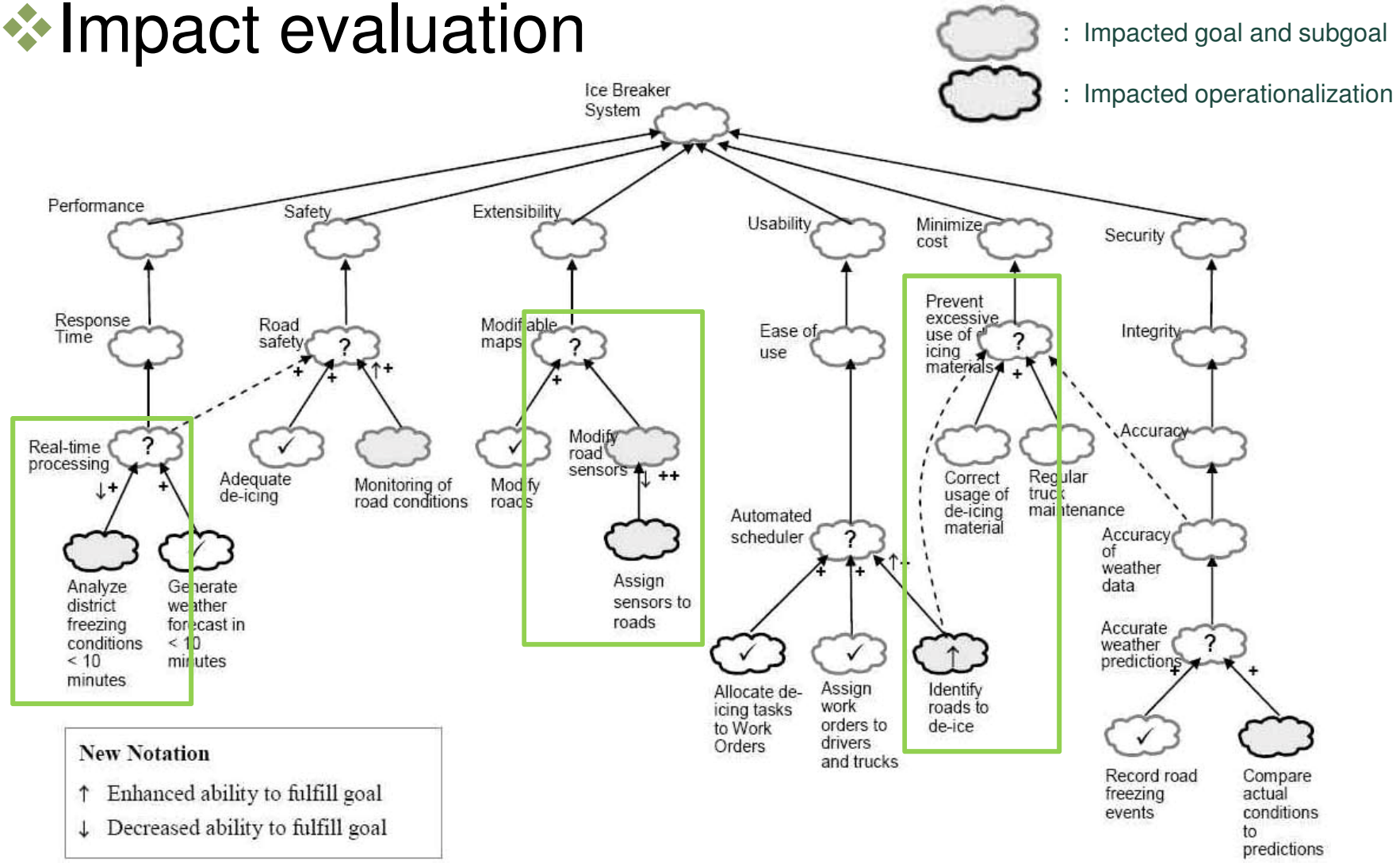
Case study(1/2)

- Impact detection(with the sequence diagram “Predict freezing conditions”)

Operationalization	Directly Related Goal	SIG Type	Probability of link to “Road Sensor” class	Probability of link to “Road” class	Action
Track truck within 50m of actual location	Real-time tracking of dispatched trucks	Performance	0.11176		Reject
Remove road sections	Modify map	Extensibility	0.07669	0.14333	Maybe
Analyze freezing conditions	**Real time processing**	**Performance**	**0.05795**	**0.10857**	**Accept**
Add new road sections	Modify map	Extensibility	0.05752	0.10750	Maybe
Monitoring of road conditions	**Road safety**	**Safety**		**0.05286**	**Accept**
Display de-iced sections of route	Onboard directions	Usability	0.04967	0.06786	Maybe
Record road freezing events	**Accurate weather predictions**	**Accuracy**	**0.04510**	**0.08036**	**Accept**
Broadcast road conditions to contacts	Monitoring of road conditions	Safety		0.03964	Maybe
Update truck status < 1 minute.	Real time communication through onboard computer	Performance	0.03725		Reject
Remove weather station	Network of weather stations	Extensibility		0.02714	Reject
Assign roads to sensors	**Modify road sensors**	**Extensibility**		**0.02571**	**Accept**

Case study(2/2)

Impact evaluation



Conclusion

- Contribution
  - Provide developers with means
    - Of notifying the impact of functional change upon NFRs
    - With tools to mitigate a user's link filtering effort
  - Show the feasibility of dynamic link retrievals
    - For NFRs
- Future work
  - Improve both recall and precision metrics
  - Analyze additional SIG types

Discussion

- Limitation
  - Low precision rate of the link retrieval method
    - But no one found the silver bullet to it yet.
  - Insufficient explanation about building SIG
    - Just referenced another paper
    - But the root cause comes from the SIG itself
  - Ambiguous targeting to the functional model
    - Source code is not directly considered with links
      - Instead, just referenced other tools