

Measuring and Improving the Completeness of Natural Language Requirements

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What is Completeness of a SRS?

Completeness

An SRS is complete if nothing is **missing** from the specification



Nothing is missing with respect to WHAT?

Different perspectives shall be considered...

Internal and Forward Completeness

Internal completeness

Nothing is missing with respect to the **specification itself**

- No To-be-determined (TBD) items
- No nonexistent references

Requires guidelines or templates

Forward completeness

Nothing is missing with respect to the **system-to-be**

- No missing specification items (e.g., missing interface specifications)
- No missing functions
- No missing products (i.e., part of the actual software that are not mentioned in the specification)

Requires a model of the system

Backward Completeness

Backward Completeness

Nothing is missing with respect to what comes before the SRS

What comes before the SRS?

- Transcripts of meeting with customers
- Preliminary specification documents
- Reference standards
- Legacy documents

Research Questions

- **RQ1.** How to **measure** the **backward completeness** of a requirements specification document?
- **RQ2.** How to **improve** the backward completeness of a requirements specification document?
- **RQ3.** Does the backward completeness **help** in improving the forward completeness of the specification?

Measuring Completeness



Defining complete requirements for a rock band



Rock'n Roll

In the earliest rock and roll styles of the late 1940s and early 1950s, either the **PIANO** or saxophone was often the lead instrument, but these were generally replaced or supplemented by **GUITAR** in the middle to late 1950s. The **BEAT** is essentially a **BLUES RITHM** with an accentuated **BACKBEAT**, the latter almost always provided by a snare drum. Classic rock and roll is usually played with one or two **ELECTRIC GUITARS** (one lead, one rhythm), a string bass or (after the mid-1950s) an **ELECTRIC BASS GUITAR**, and a **DRUM KIT**.



Requirements for My Band

- My Band shall have **ELECTRIC GUITARS**
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Backward Completeness

Backward Completeness

All the relevant **concepts** and **interactions** among concepts expressed in the input documents are also treated in the requirements

We distinguish between:

- Concept Completeness
- Interaction Completeness

Relevant Terms

- Relevant concepts can be approximated with the **relevant** terms of the input documents
- A term is a single word (e.g., “guitar”) or a multi-word term (“rock and roll”)

Concept Completeness



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The **PIANO**!

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Relevant Relations among Terms

- Relevant interactions can be approximated with **relevant relations** among terms
- Pairs of relevant terms that occur in the same sentence of the input documents form a relevant relation
- **GUITAR** is normally a lead instrument in **ROCK AND ROLL**

Interaction Completeness



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The
BACKBEAT in
the **RITHM**!

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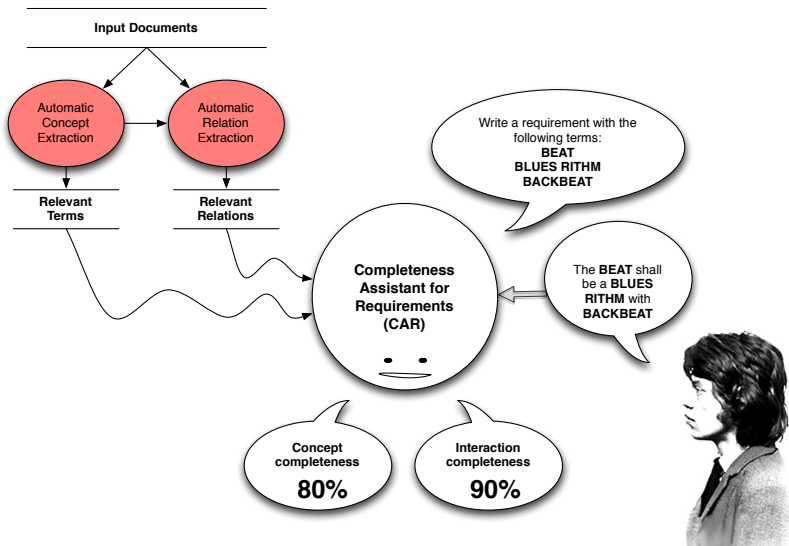
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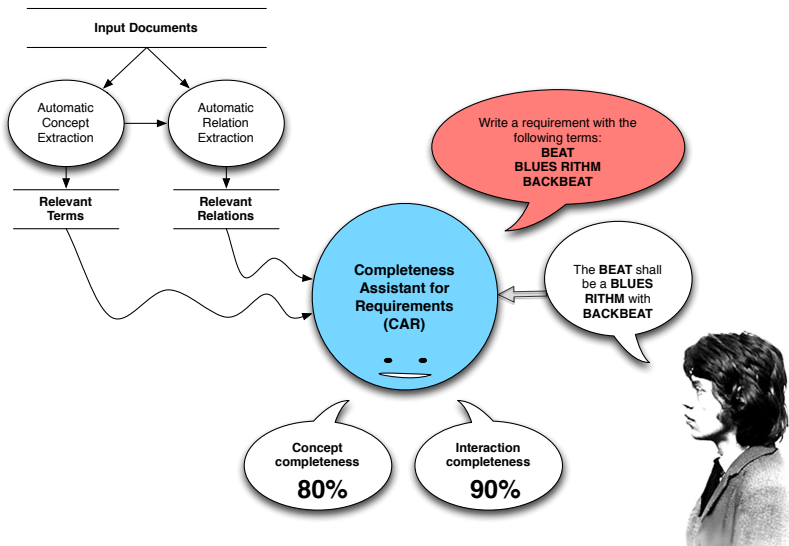
A Word Game to Improve Completeness



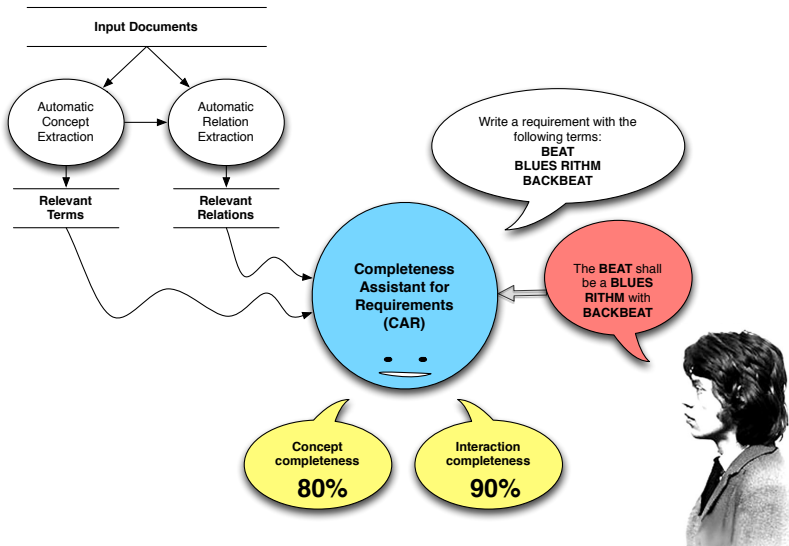
Completeness Assistant for Requirements



Completeness Assistant for Requirements



Completeness Assistant for Requirements



Completeness Assistant for Requirements

Completeness Assistant for Requirements

Write a requirement with the following terms:

conductor

control

train doors

Get other terms

Suspend Terms

Suspend Relations

The ATS system shall notify the inhibition of control of the train doors to the train conductor

5. The ATS system shall receive train location information from the trains
6. The ATS system shall support a function to force a train to skip a station
7. The ATS system shall support a function that allows the inhibition of control of the train doors

Add

Concept Completeness 0.0859

Interaction Completeness 0.0247

For trains operated with crews, this function is optional and shall be as specified by the authority having jurisdiction. If this function is provided, a CBTC system may indicate the train hold information to the train operator and conductor on their displays, and/or prevent a CBTC-equipped train from departing the station in ATO mode.

6.3.6.3 Skip station stop.

An ATS system may include facilities to direct a CBTC-equipped train or group of CBTC-equipped trains to pass through a station or group of stations without stopping. For trains operated with crews, a CBTC system may indicate the skip station information to the train operator and conductor on their displays. In ATO mode, the train shall automatically skip the designated stations.

6.3.6.4 Door control inhibit.

An ATS system may include facilities to inhibit (and subsequently permit) CBTC control of the train doors, in accordance with 6.2.3.

Experiment



Automatic Train Supervision (ATS) System

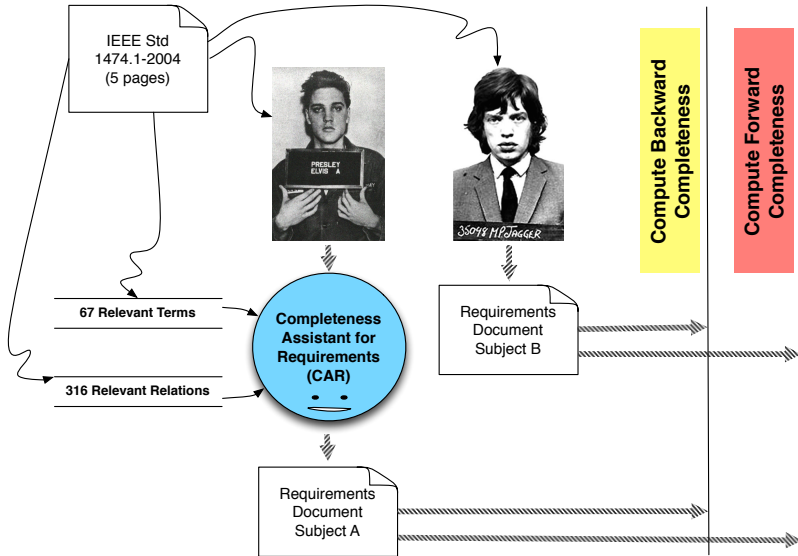
ATS System

- Centralized system that monitors and regulates the movement of the trains
- Automatically routes trains, and sends them speed profiles that shall be followed while moving through the railway network
- Normally equipped with a user interface where the ATS operator can view the position of all the trains, their schedule, and other information

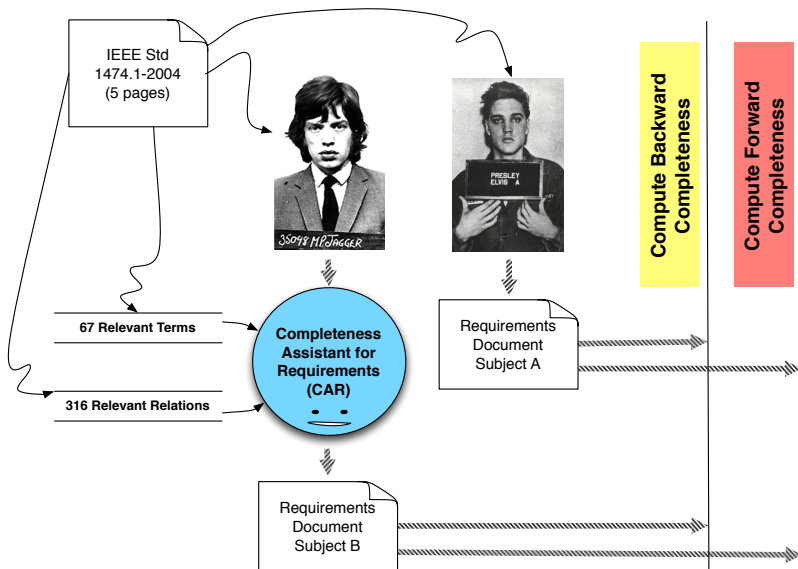
Input Document

The IEEE Std 1474.1-2004 includes the basic requirements of an ATS system

Experiment: Phase 1



Experiment: Phase 2



Results

Subject	Num. Reqs	Tool	<i>degCC</i>	<i>degIC</i>	<i>degFEC</i>	<i>degLCC</i>
A	36	Yes	68.7%	17.1%	47.6%	40%
		No	52.3%	12.8%	61.9%	50%
B	21	Yes	67.2%	24.5%	47.6%	50%
		No	58.2%	11.6%	33.3 %	50%

Backward completeness increases when the tool is used

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- We did not find a positive correlation between backward and forward completeness
- A positive correlation holds only for Subject B

Conclusion

- A new method has been developed to measure completeness
- A new method has been developed to improve completeness
- Backward completeness did not imply forward completeness
- Requirements definition needs **background + [...]** to achieve forward completeness
- The requirements edited with CAR tend to be more specific
 - ▶ “The ATS system shall adjust the speed profile of the trains in response to wet rail conditions in order to avoid emergency brake application” (**specific case**)
 - ▶ “The ATS system shall be capable of supporting re-routing of trains in response to service disruption” (**alternative behaviour**)
- The tool can have a **complementary role** in requirements definition

Questions?

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