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Ontology Evolution and Regression Analysis

Insights into Ontology Regression Testing

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Motivation

Current studies of Ontology Evaluation tend to:

- Focus on individual ontology versions
- Focus on shifts in the gross statistics

In either case we don't get objective and systematic evaluations of the life span of the ontology

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Our goal is to extract insightful and useful information out of all the existing versions of an ontology

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Ontology Testing Challenge

- How do we systematically identify test areas?
- How do we systematically analyse change impacts to the ontology?

How can we effectively minimise testing efforts and cost and still achieve adequate testing coverage

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Software Testing

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Software Regression Testing
What is it?

- It is a test activity to systematically re-test existing components after software changes

- It test against current and updated requirements

Software Regression Testing
Testing Aspects

- Testing at the functional requirements
  - Unit Level
  - System Level
- Testing at the non-functional requirements

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Software Regression Testing
Testing Plan

- Defines testing criteria
- Identifies test area or components
- Test execution strategy
- Test evaluation strategy
- Updates test and other relevant documentation

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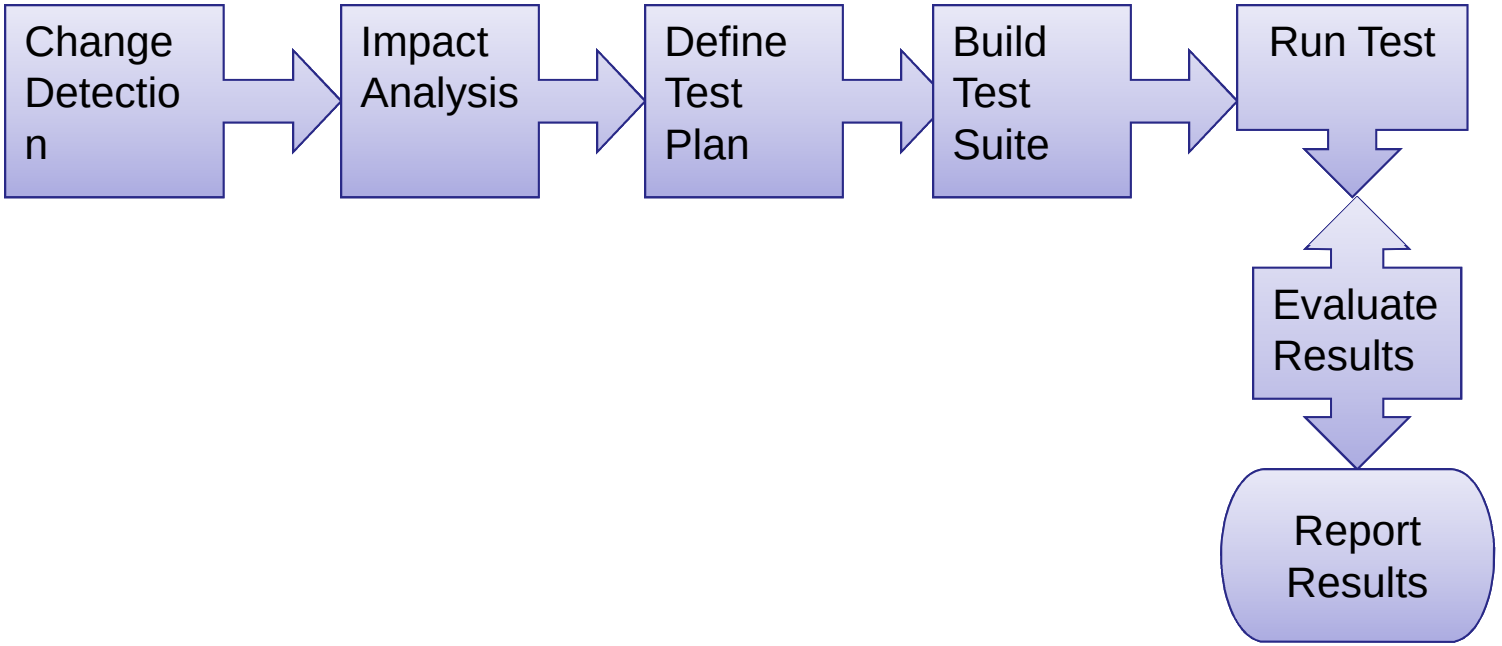
Software Regression Testing Process



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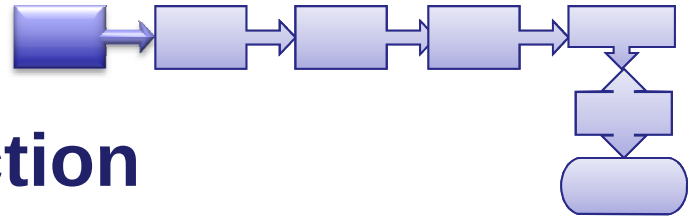
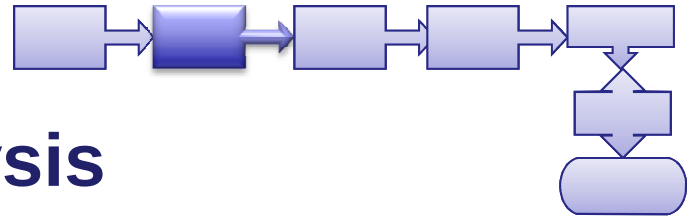
Ontology Regression Testing?



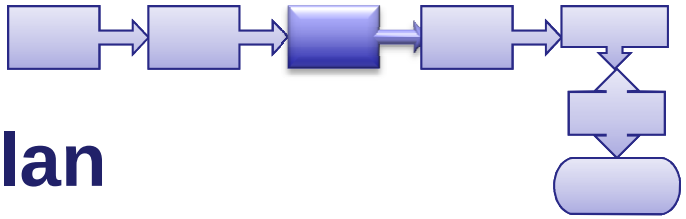
Change Detection

- Explicit Changes
  - Asserted logical and annotation axioms
  - Properties
  - Classes
- Implicit Changes?
  - Subsumption changes
  - Entailment changes



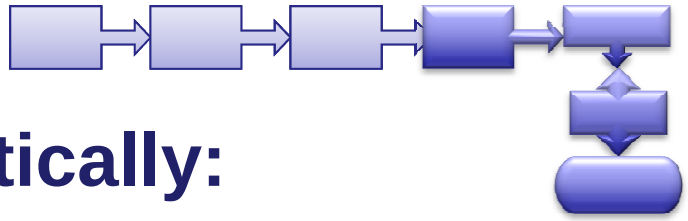
Impact Analysis

- Previous Version or all versions?
  - Intentional Difference analysis?
  - Justifications analysis?
- Information Content?
  - Asserted content?
  - Entailed content?
- Requirements Impact?
  - Functional and Non-functional?
  - Which ones do we test?



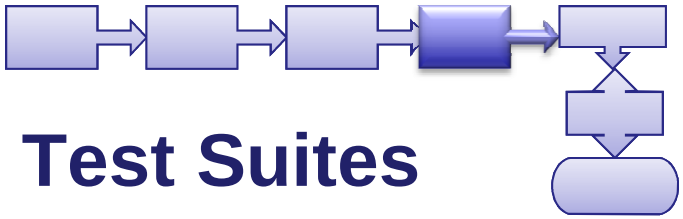
Define Test Plan

- Test criteria?
- Test area? Do we have test areas?
- How can the test be systematically run?
- Can results be interpreted?



Can we systematically:

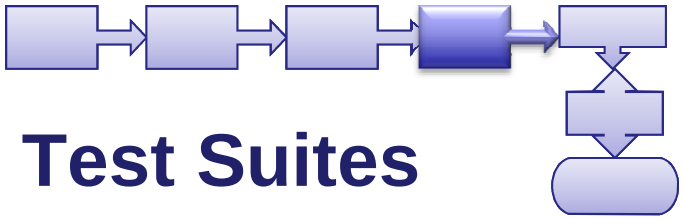
- Build test suites?
- Run tests?
- Evaluate results?
- Re-run tests if necessary?



Manual vs. Automated Test Suites

- Manually test cases
  - Check against a methodology
  - Eyeballing

- Automated test cases
  - Satisfiability
  - Inconsistency



Manual vs. Automated Test Suites

- Manually test cases
  - Time consuming
  - Subjective
  - Unsystematic
- Automated test cases
  - Reasoner based
  - Limited in scope

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Can we expand the range of automatic test suites?

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YES

By Analysing Ontology Dynamics

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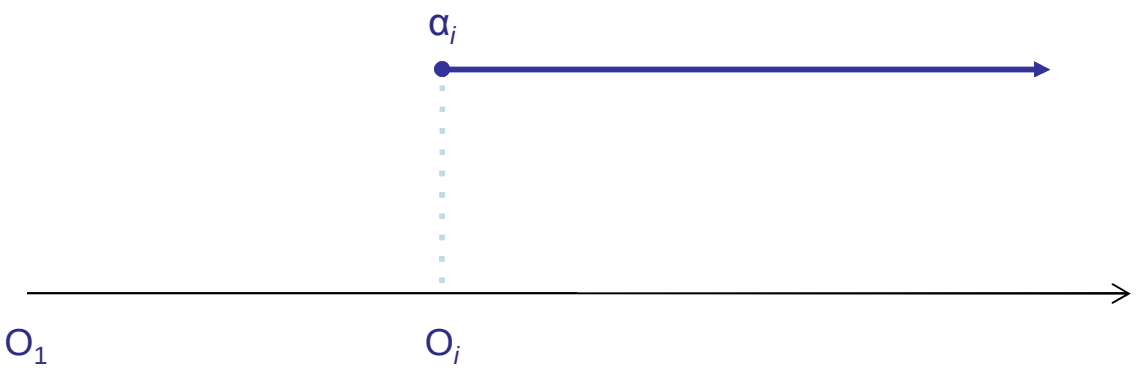
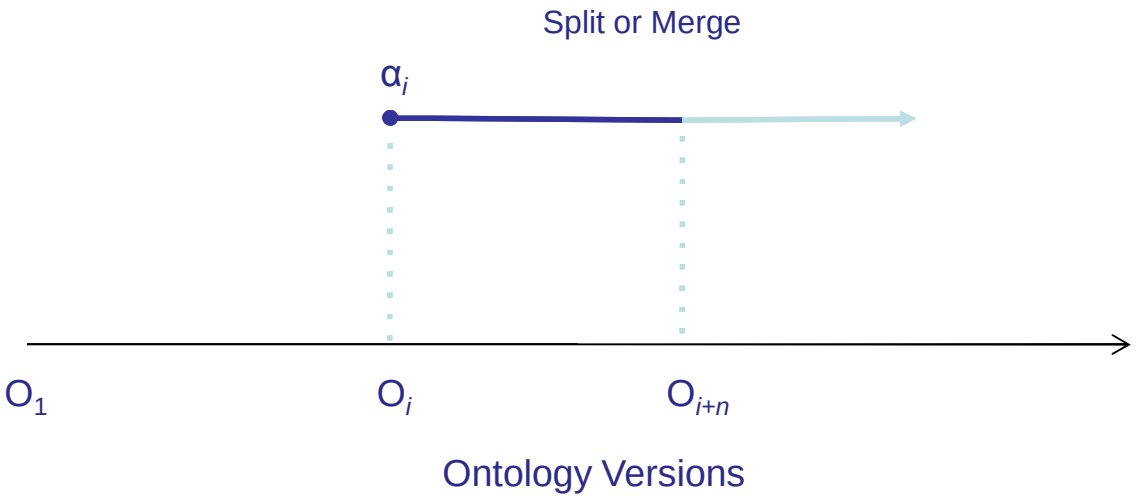
What are Ontology Dynamics?

- Periods of growth, decline, and stability
- Axioms presence
- Types of axioms presence (e.g. continual, interrupted)
- Sequence editing types and patterns

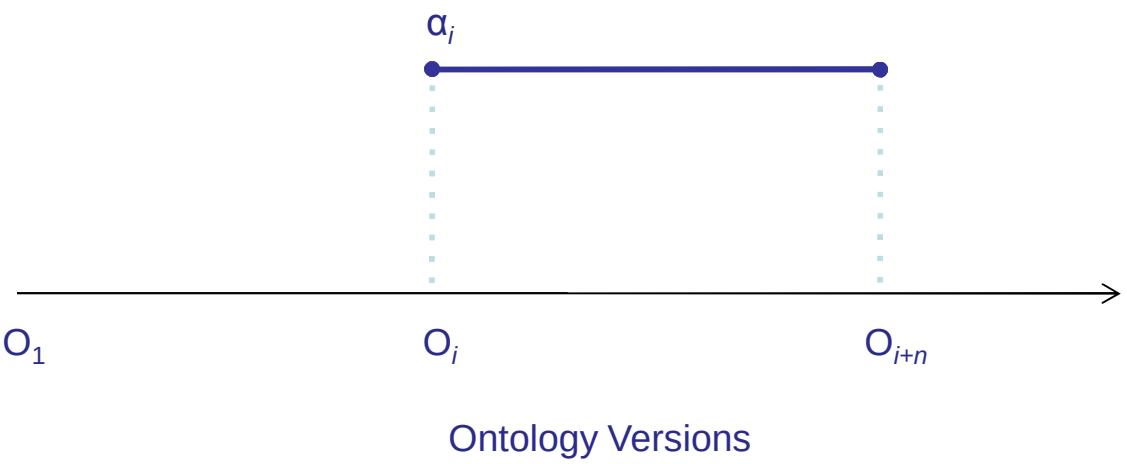
Axiom Life Span - We expect:
Axioms with Constant Unchanged Presence



Axiom Life Span - We expect: Axioms that are Modified



Axiom Life Span - We expect: Axioms that Enter and Leave the Ontology



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NCIt Ontology Dynamics

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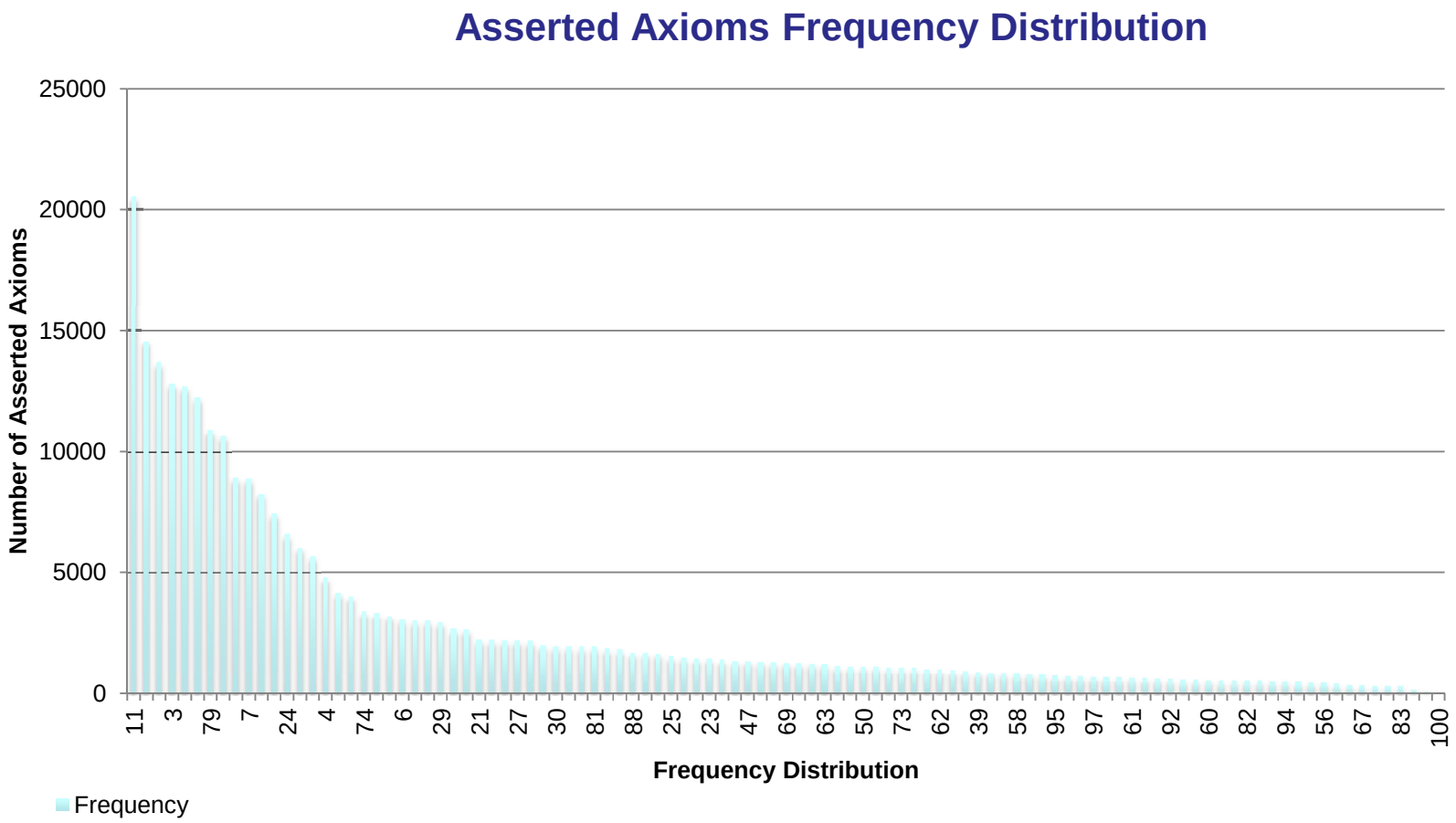
National Cancer Institute Thesaurus (NCIt)

- The National Cancer Institute (NCI) is a U.S. government funded organisation for the research of causes, treatment, and prevention of cancer
- The NCIt is an ontology written in the Web Ontology Language (OWL) which supports the development and maintenance of a controlled vocabulary about cancer research
- Multiple publications about process, quality control, usage, and critiques
- Publicly available monthly releases and concept change logs

Rich source of ontology evolution data

NCIt Dynamics – Axioms Life Span Analysis



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NCIt Change Dynamics – Detailed View of Axiom Life Span

Frequency	Axiom Count	Appearing in version 103	Consecutive Appearance	Non-consecutive Apperance
11	20,520	358	99.67%	0.33%
5	14,586	831	99.99%	0.01%
2	13,680	445	76.80%	TBC
3	12,806	664	99.98%	0.02%
87	12,689	12,669	99.86%	0.14%
1	12,219	47 version 102; 2,084 version 103	N/A	N/A
79	10,910	10,866	99.93%	0.07%
8	10,662	599	99.93%	0.07%
103	8,933	8,933	100.00%	0.00%

Top Ten Frequency Distributions

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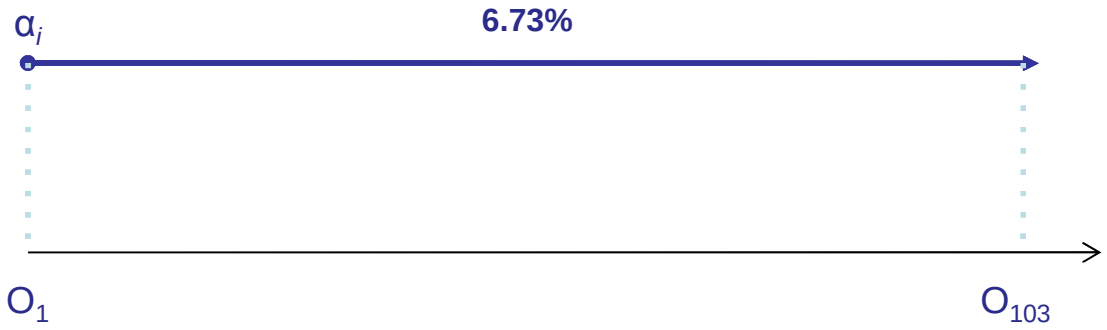
NCIt Axiom Life Span: Axioms with Constant Unchanged Presence



NCIt 2003 – 2012
103 Versions

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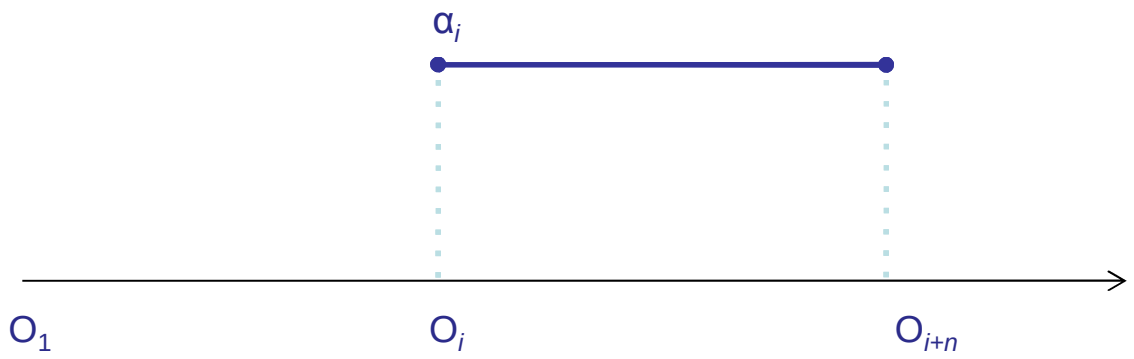

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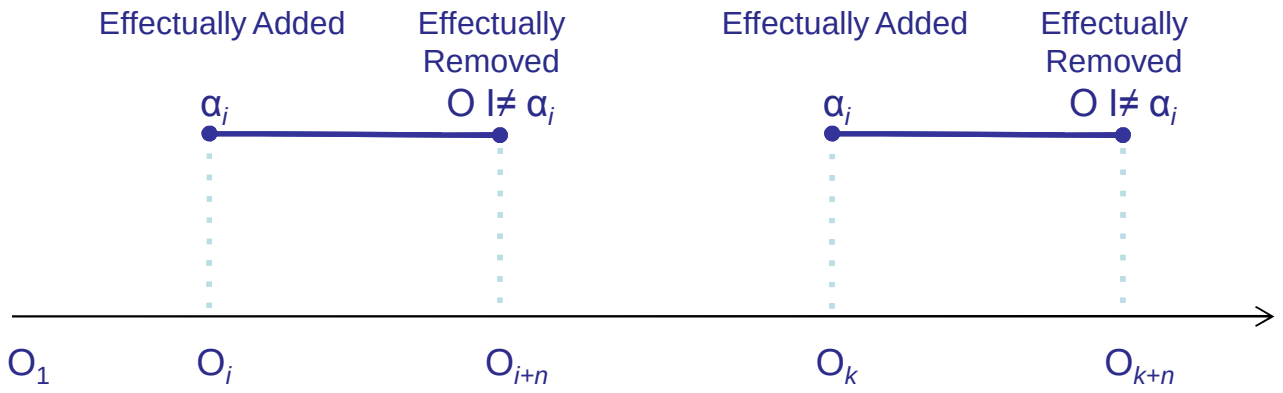
NCIt Axiom Life Span: Axioms with Gaps between Unchanged Presence



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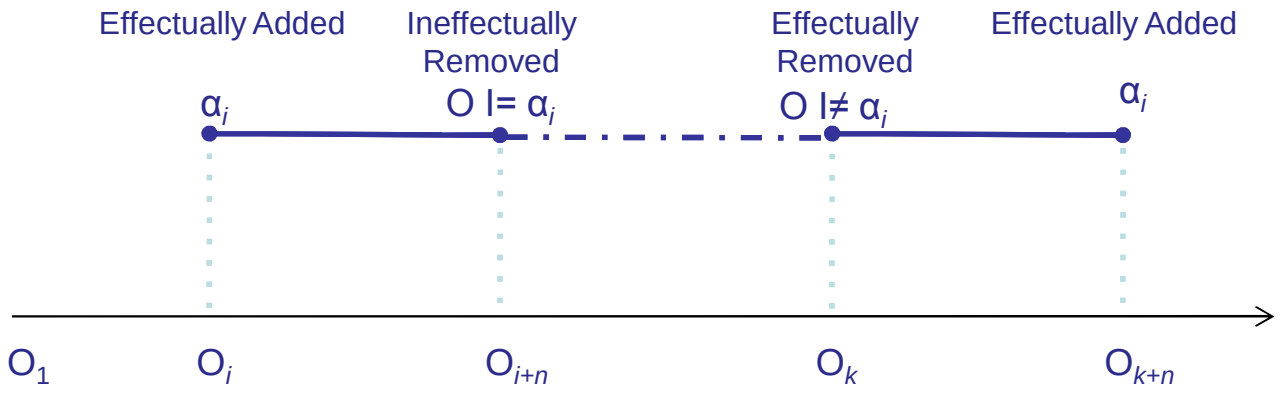

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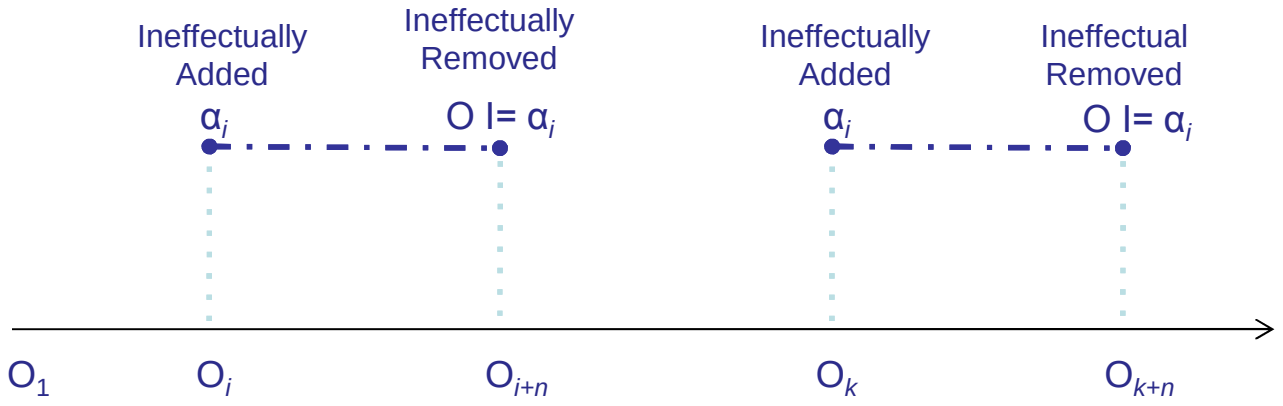

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NCIt Dynamics – Editing Patterns

Frequency rate	Axiom IDs	First version in NCIt	Effectual addition version	Effectual removal version	Ineffectual addition version	Ineffectual removal version	Last version in NCIt
11	57506, 58364	4	4, 7	5, 17			16
	103206, 105069	7	7	26	25	17	25
	110594	10			10, 31	20, 32	31
	210295	40	40, 51	47, 55			54
	215592, 215897	50	50		98	55	103
5	157661	20	20		45	24, 46	45
2	49544, 50602	2	2, 4	3, 5			4
	50858	2	2, 18	3, 19			18
	99659	6	6	17	16	7	16
	120551	12	12, 16	13, 17			16
	127241	16	16		21	17, 22	21
	172613, 172917	25	25, 62	26, 63			62
3	159025	21	21, 27	22		29	28
	257839	83	83, 93, 103	84, 94			103
87	3241	1	1		23	7	103
	12085	1	1		33	17	103
	30433	1	1, 14, 89	12, 75			103
	39267	1	1, 18	2			103
	68617	5	5, 18	6			103
	106537, 106569, 106569, 107407, 107860, 107952, 108468	9	9		25	17	103
	111380, 114579	10	10		24	17	103
	118516, 119326	12	12, 79	74			103
	121919, 122832	13	13, 51	47			103
79	6838, 44135	1	1	86	23	17	85
	8905	1	1, 30	6			103
	42533	1	1		41	17	103
	44135	1	1	86	23	17	85
	125718, 125895	15	15, 29	19			103
	162303	23	23, 94	93, 103			102
	162304	23	23, 36	34			103
8	22465	1	1	52	45	2	51
	67505	5	5, 10	6, 17			16
	153578	17			17, 20	18, 27	26
	215709	50	50		99	53	103
	238416, 238488	72	72, 103	79			103
	262226	87	87, 94	93, 96			95

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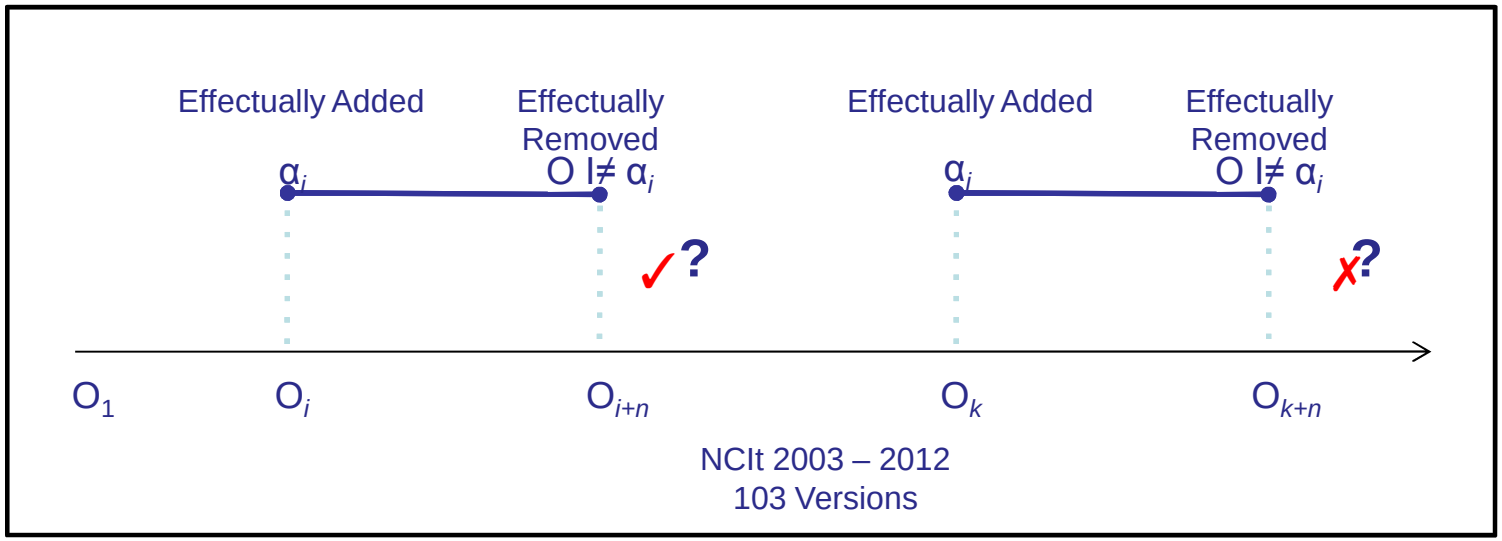
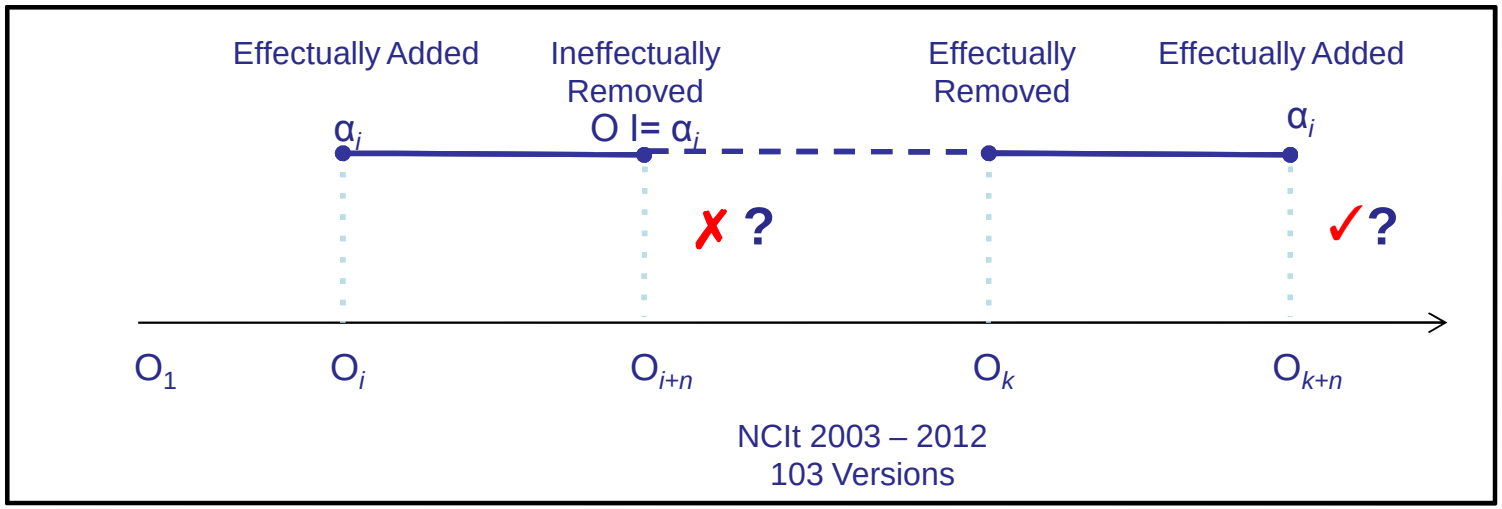
NCIt Regression Analysis – Main Finding

This means that we are able to identify 'bugs', the sequence pattern of these bugs, and their location!

NCIt Regression Analysis: Indicative of Faults In Sequence of Changes





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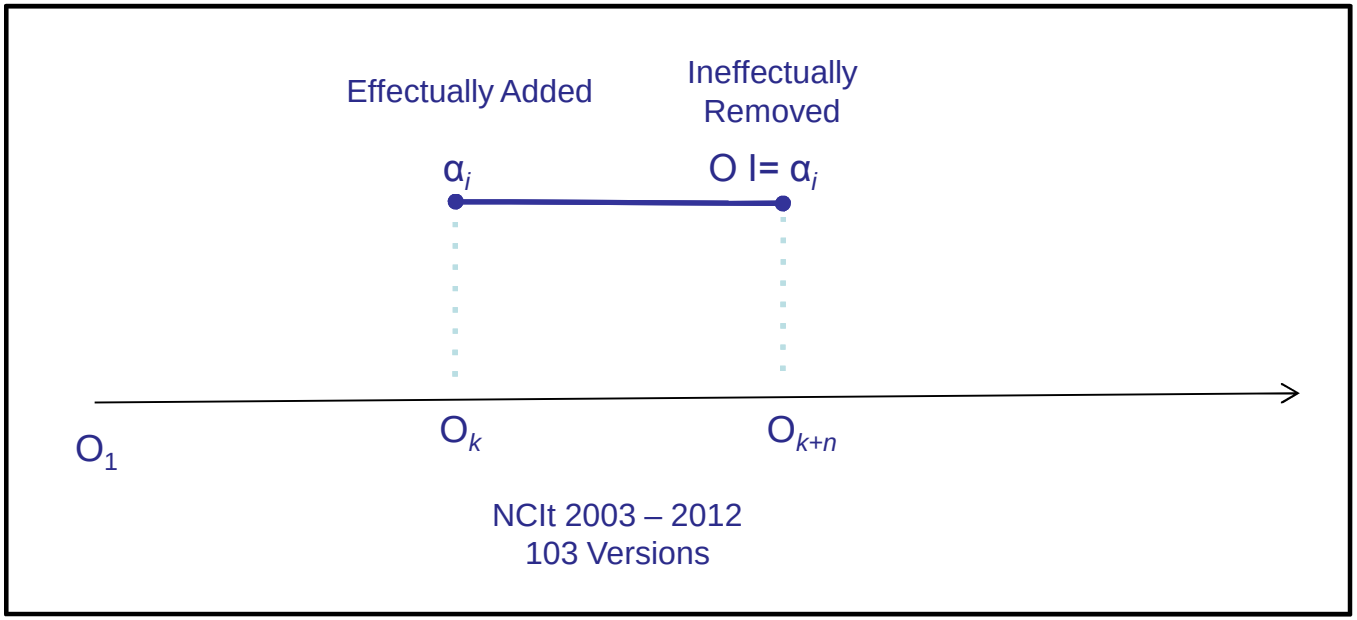
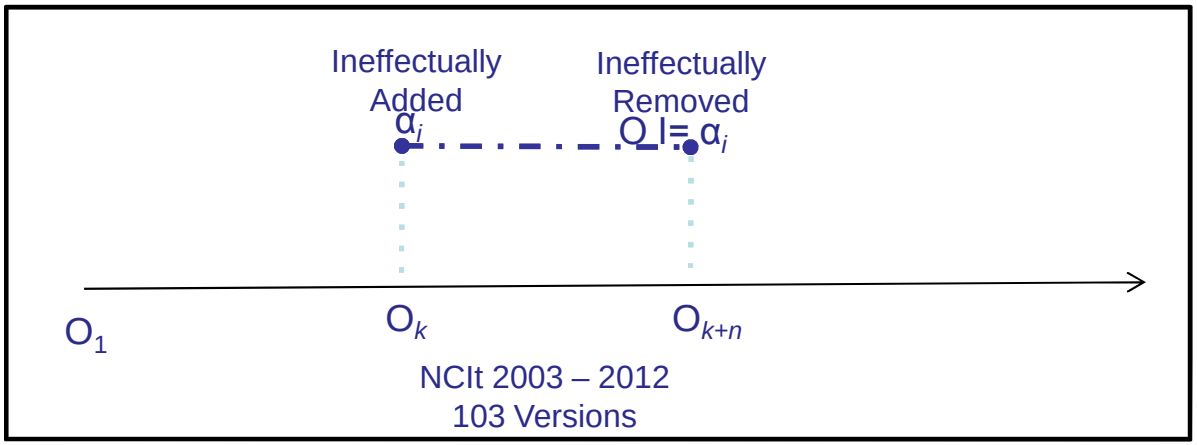
NCIt Regression Analysis: Suggestive of Faults In Sequence of Changes

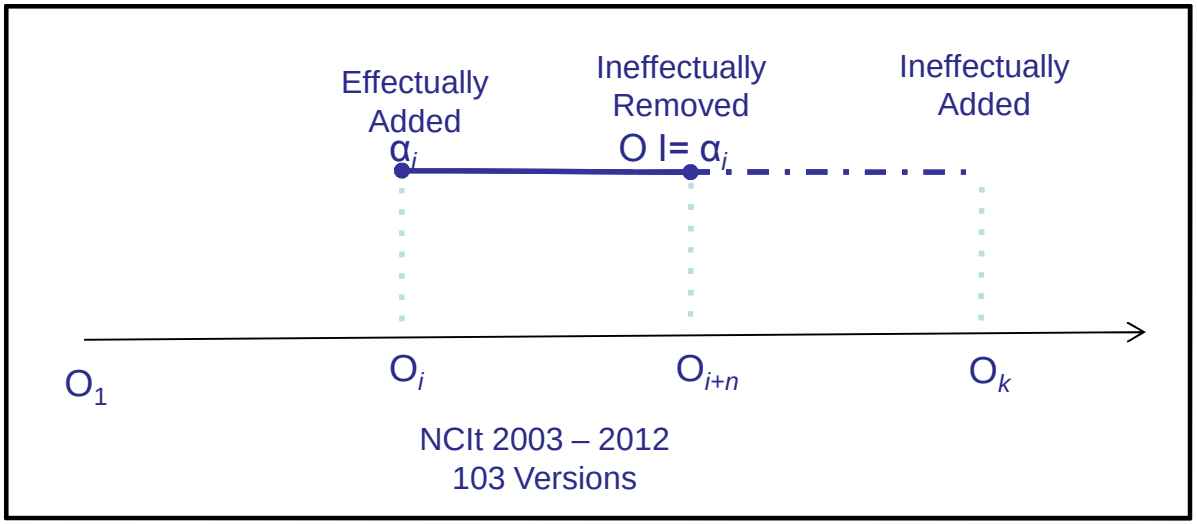


Refactoring

NCIt Regression Analysis: Suggestive of Faults In Sequence of Changes



?



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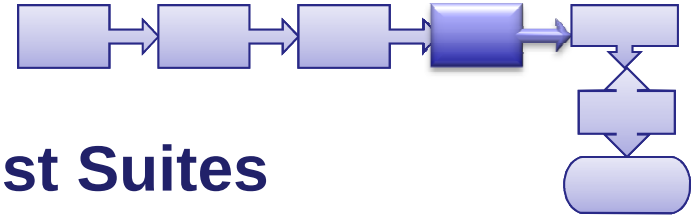
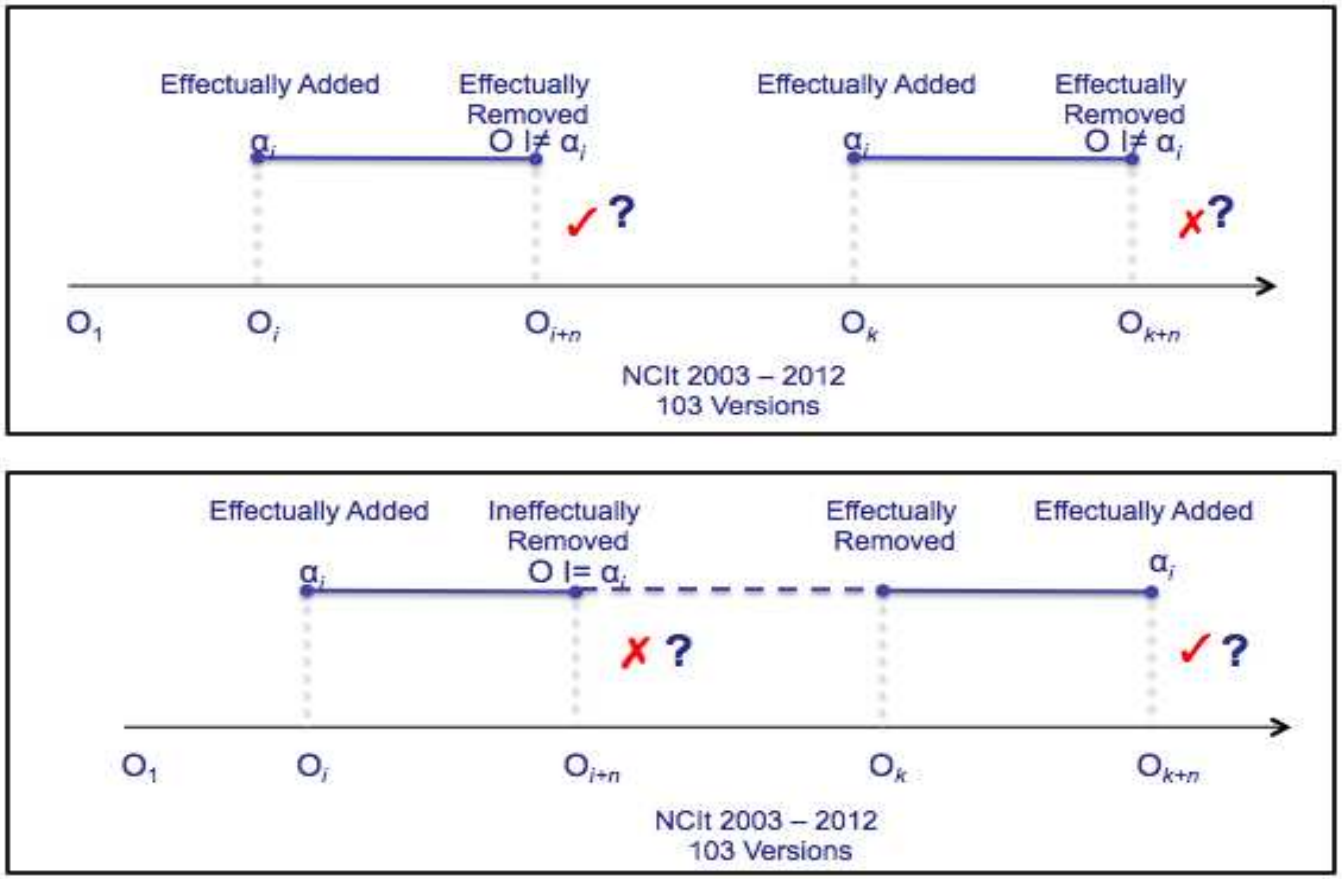
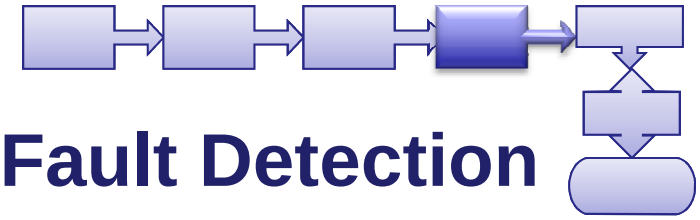
From Change Dynamics to Ontology Regression Testing



Systematically Build Test Suites



<u>Indicative</u> of Faults In Sequence of Changes



Automated Test Suites - Fault Detection

- It provides systematic regression test for all version of the ontology
- It conclusively identifies content regression and content refactoring
- It suggests other faults based on regression sequence

It is efficient and cheap to run

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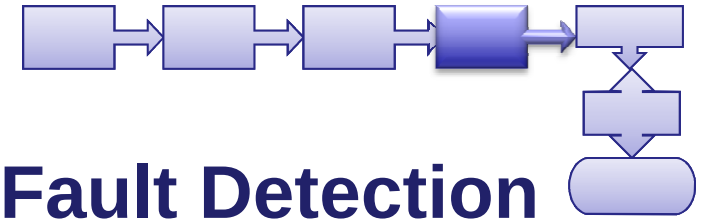
And there are still more potential benefits …



Automated Test Suites - Fault Detection

- Entailment Set Studies
- Sub Domain Dynamics
- Ontology Classes Dynamics

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Thanks

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Graphs Key

Axiom's presence in the assert and entailments sets (effectual addition)

Axiom's presence only in the entailment set or the asserted set (ineffectual addition)