

On the Use of Sequence Mining within Spectrum Based Fault Localisation

Gulsher Laghari and Serge Demeyer

SAC-SVT2018, Pau France - April 12, 2018

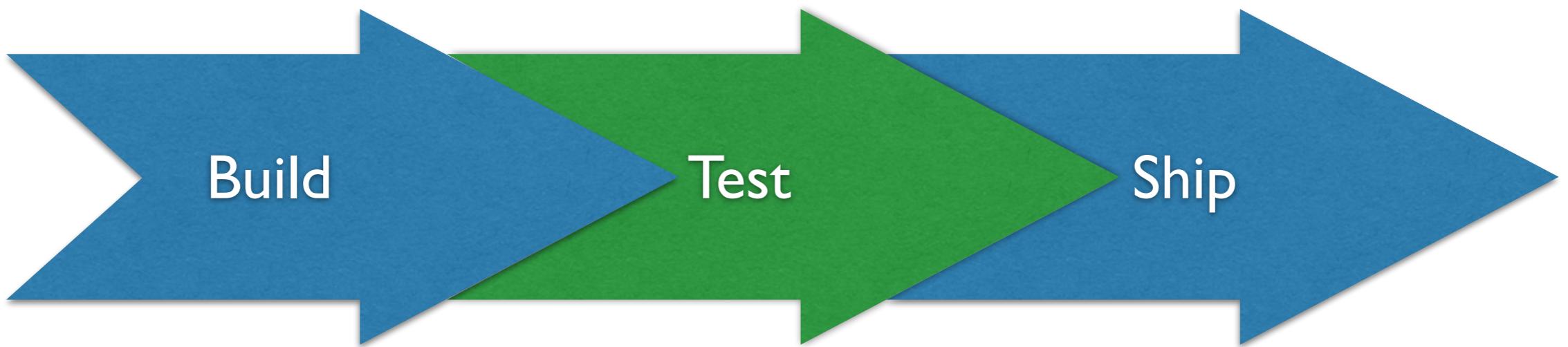


Ansymo

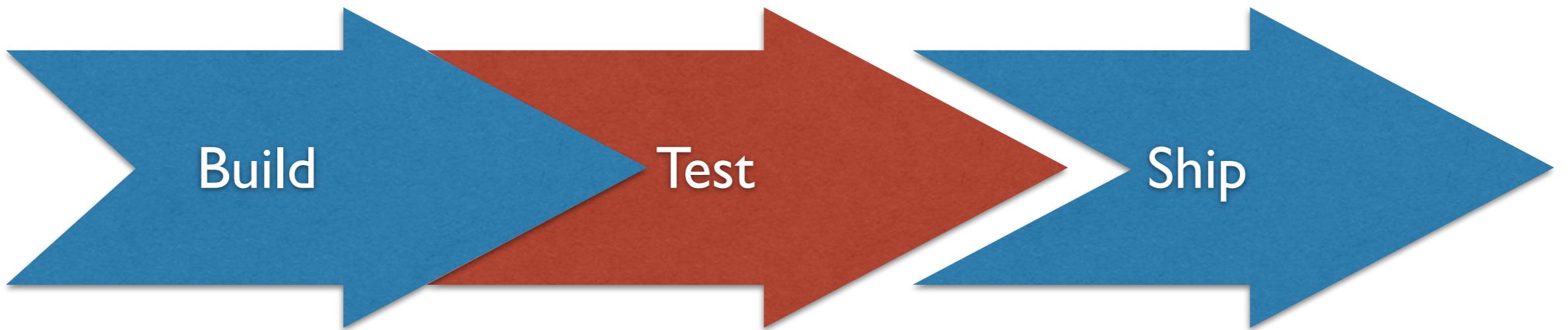
Antwerp Systems & Software Modelling
University of Antwerp



Overview



Overview



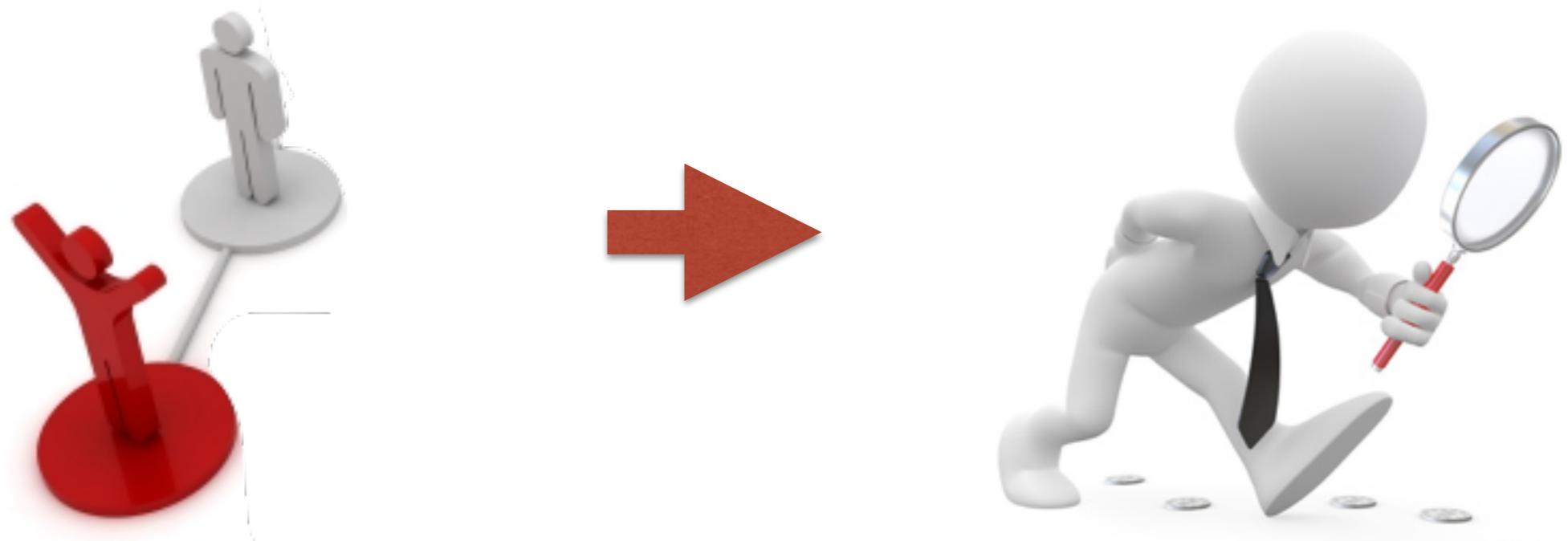
Fault Localisation



Fault Localisation an important step in debugging process

Fault Localisation

Test to code mapping - 1:1



Fault Localisation

Test to code mapping - 1:N



Fault Localisation

```
public void testGetMaxMiddleIndex() {  
    TimePeriodValues s = new TimePeriodValues("Test");  
    assertEquals(-1, s.getMaxMiddleIndex());  
    s.add(new SimpleTimePeriod(100L, 200L), 1.0);  
    assertEquals(0, s.getMaxMiddleIndex());  
    s.add(new SimpleTimePeriod(300L, 400L), 2.0);  
    assertEquals(1, s.getMaxMiddleIndex());  
    s.add(new SimpleTimePeriod(0L, 50L), 3.0);  
    assertEquals(1, s.getMaxMiddleIndex());  
    s.add(new SimpleTimePeriod(150L, 200L), 4.0);  
    assertEquals(1, s.getMaxMiddleIndex());  
}
```

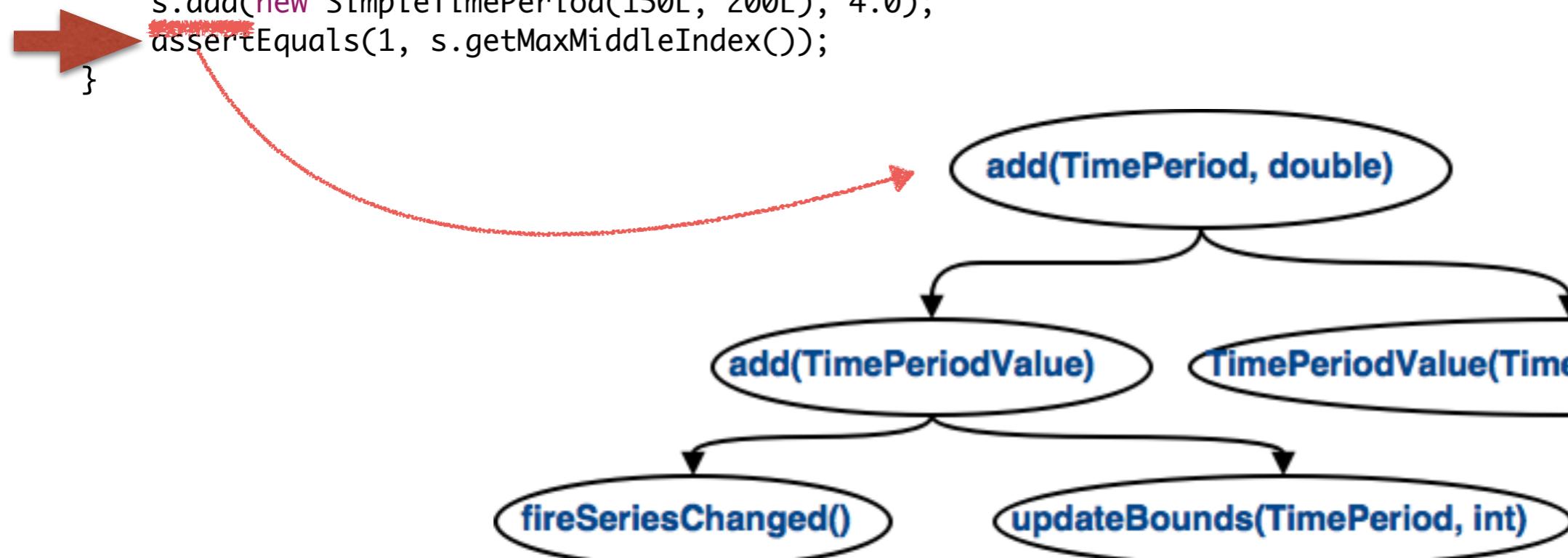


* Failing test in Apache Commons Math

Fault Localisation

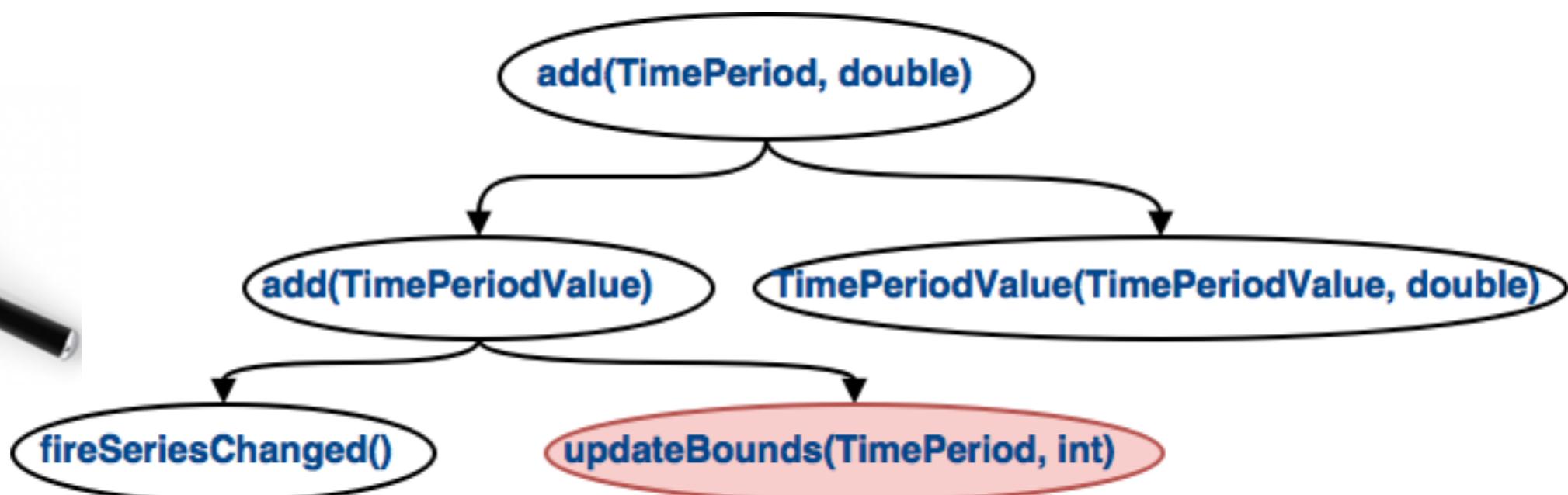


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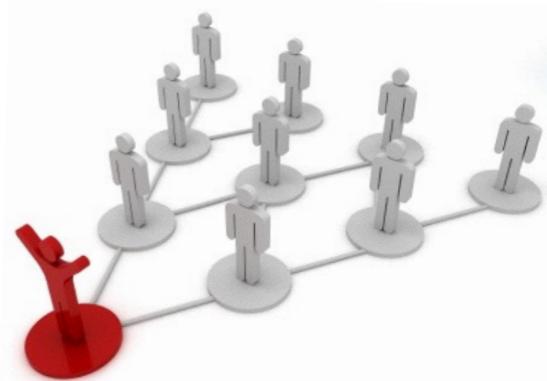
Fault Localisation

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```

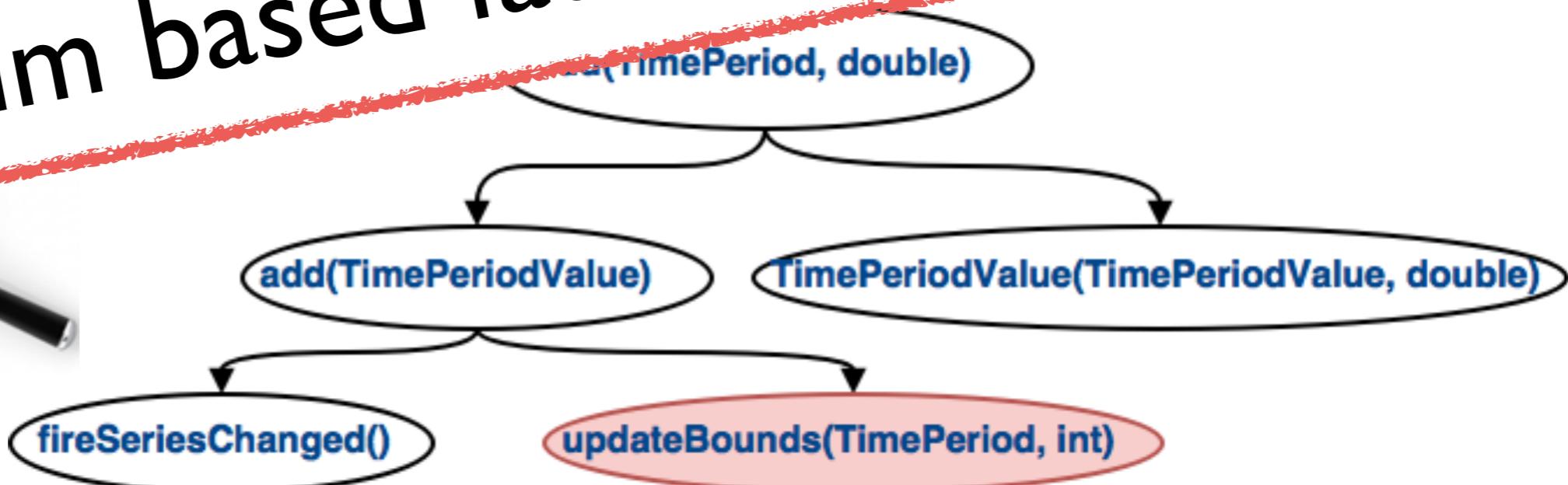


Fault Localisation

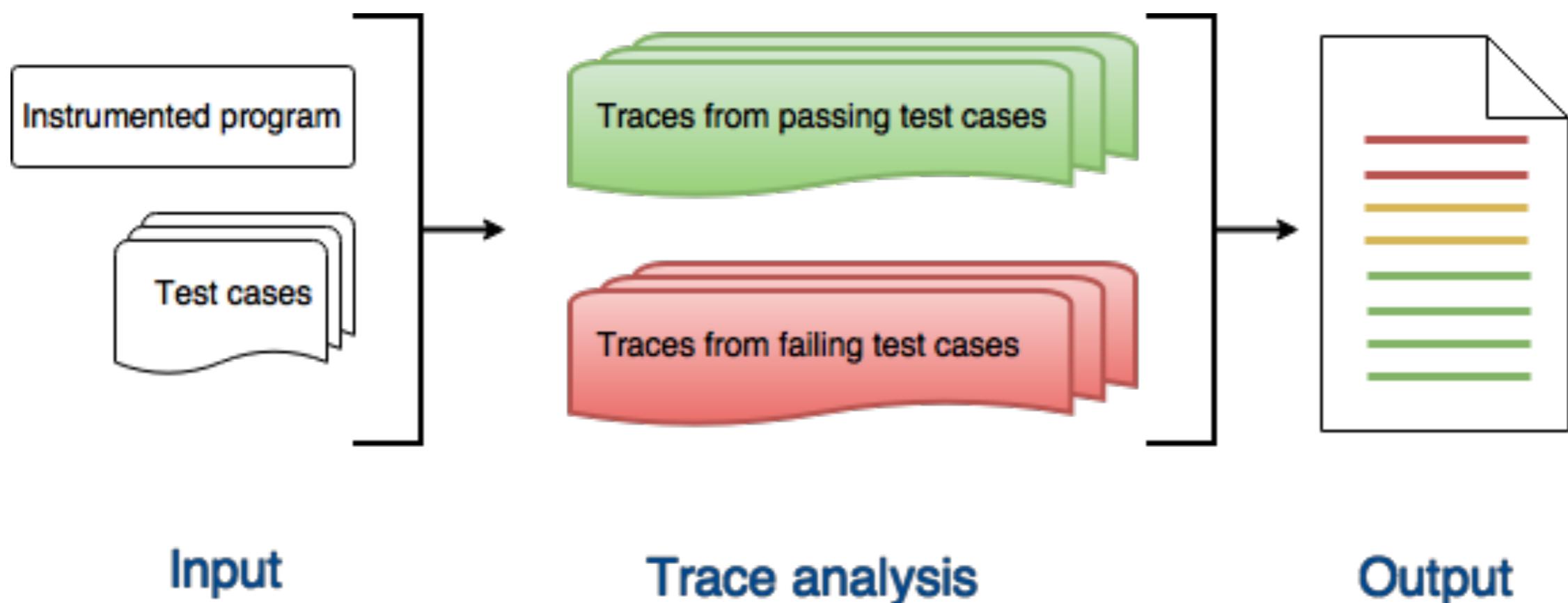
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```



Spectrum based fault localisation

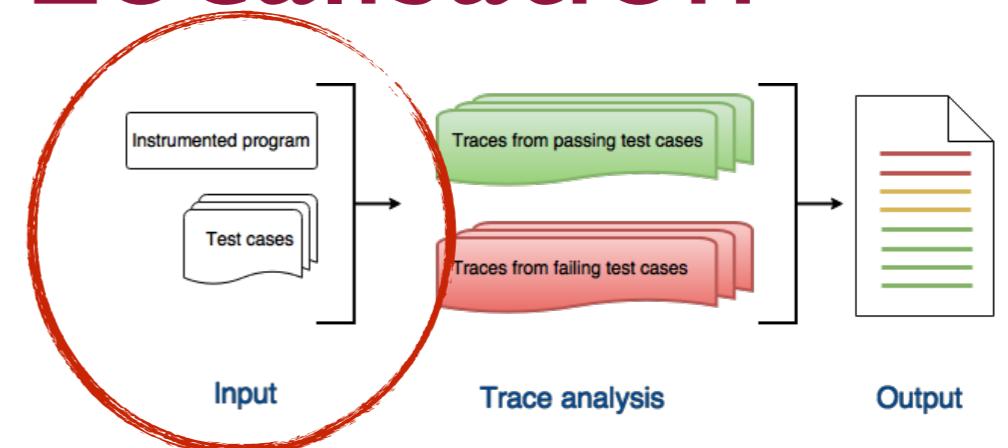


Spectrum Based Fault Localisation

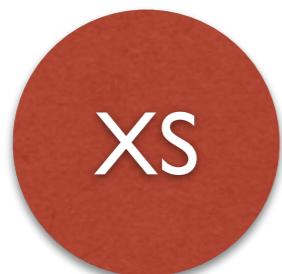


Spectrum Based Fault Localisation

Granularity



Statement



Block



Method

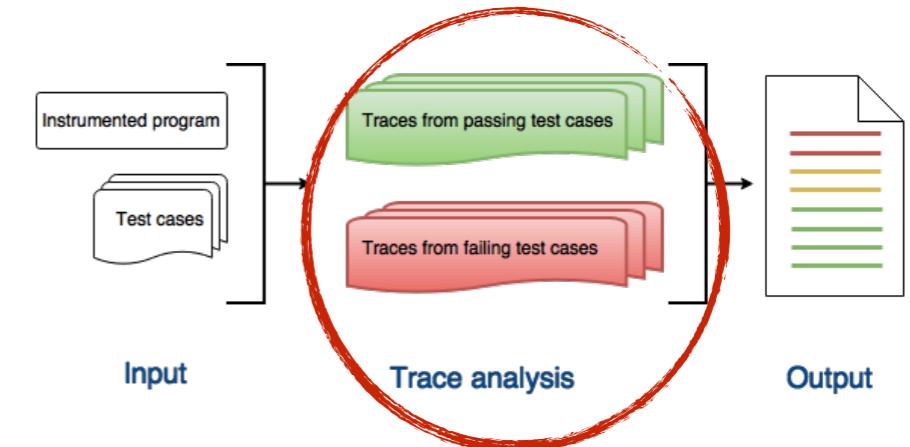


Class

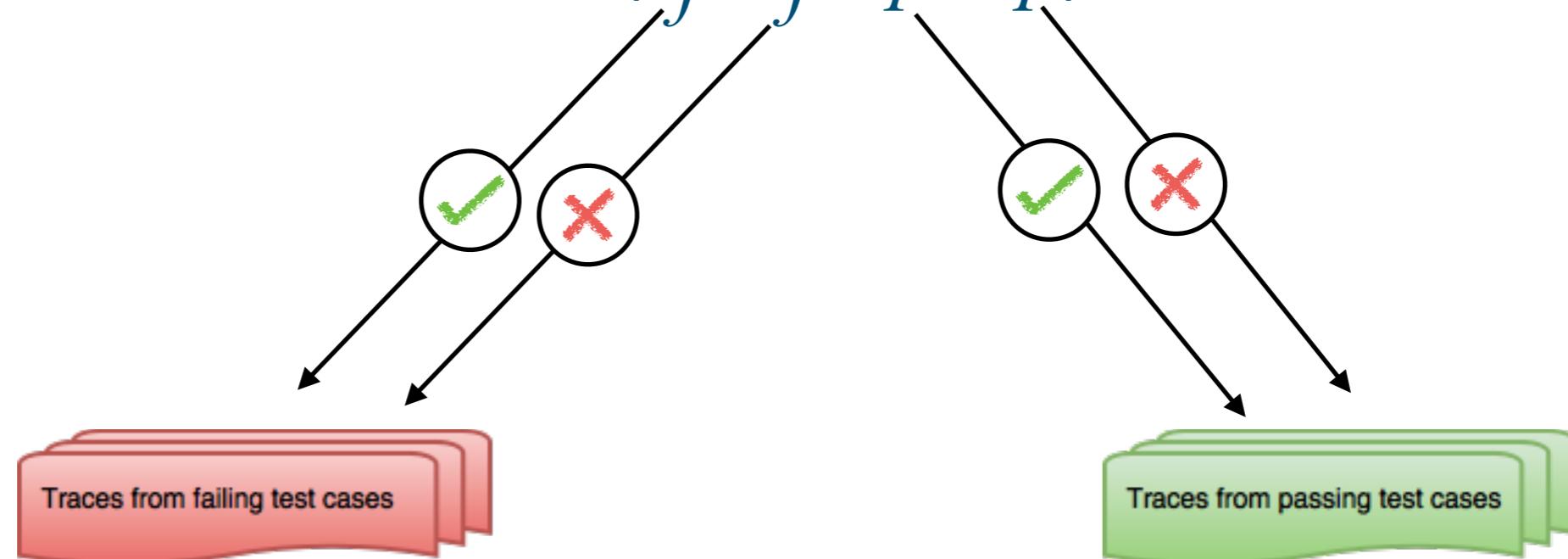


Spectrum Based Fault Localisation

Hit Spectrum



$$\text{Method} = (e_f, n_f, e_p, n_p)$$

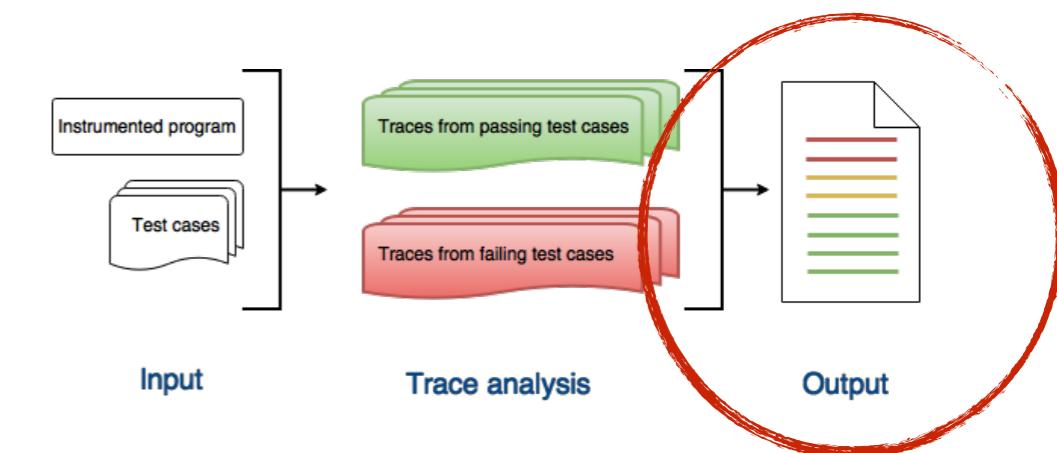


Number of traces that contain UUT

Number of traces that do not contain UUT

Spectrum Based Fault Localisation

Fault Locator



$$f(x)$$

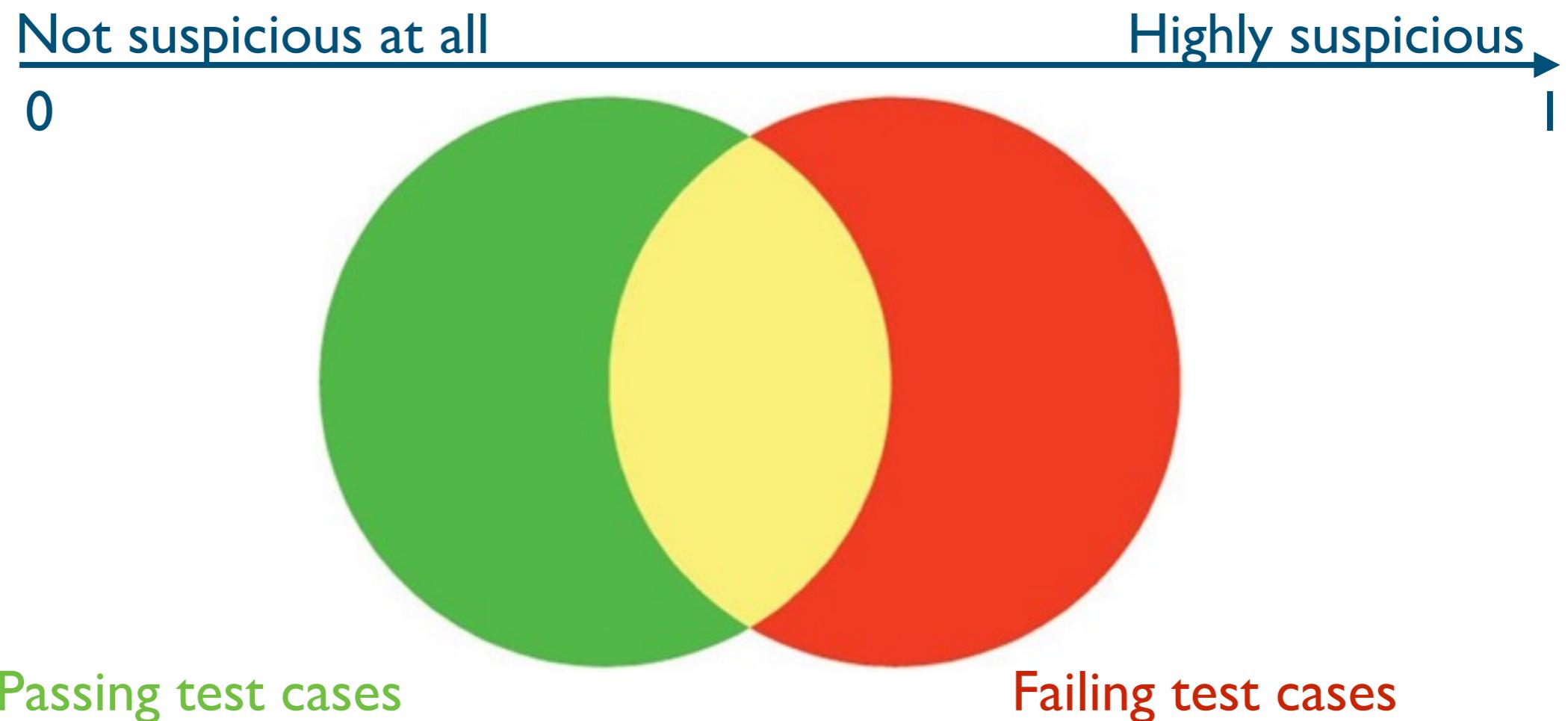
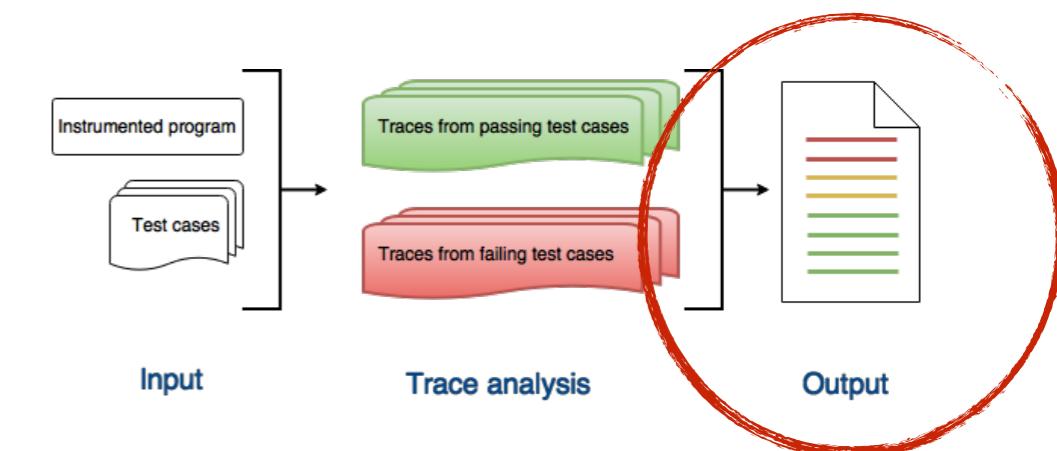
Method = (e_f, n_f, e_p, n_p)

Method = Suspiciousness [0,1]

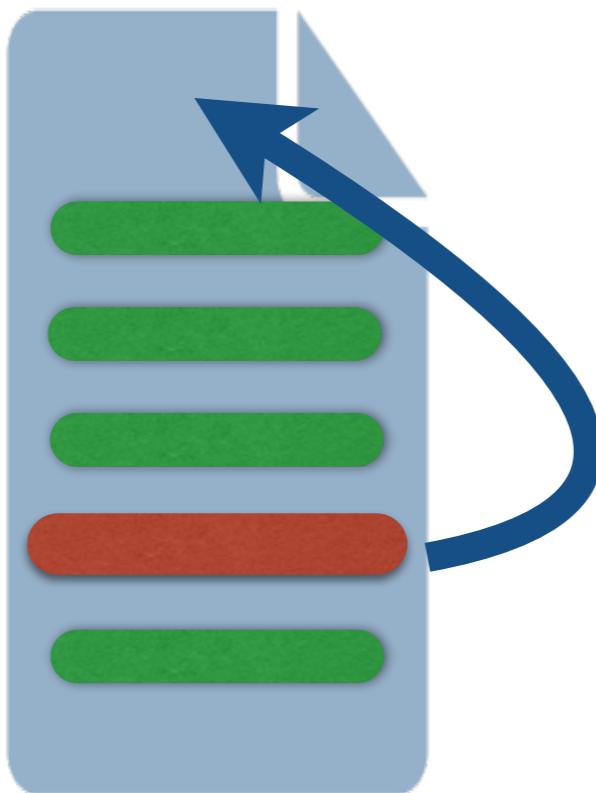
$$suspiciousness = \frac{e_f}{\sqrt{(e_f + n_f)(e_f + e_p)}}$$

Spectrum Based Fault Localisation

Fault Locator



Spectrum Based Fault Localisation



Spectrum Based Fault Localisation



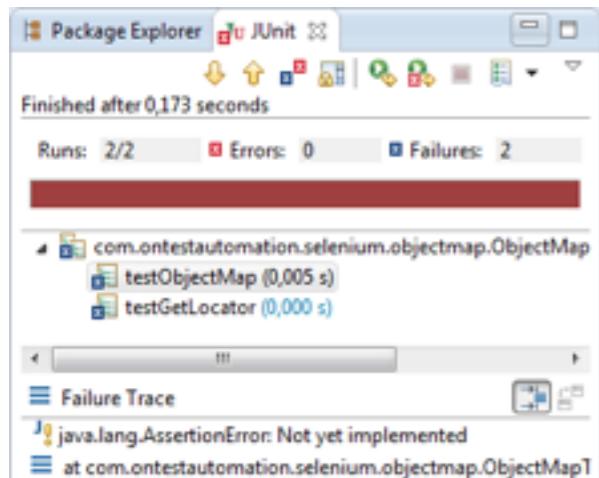
Raw Spectrum Analysis

Missing

```
method1( ) {  
    methodA( )  
    methodB( )  
    if (condition) {  
        return  
    }  
    methodC( )  
}
```

Raw Spectrum Analysis

Missing

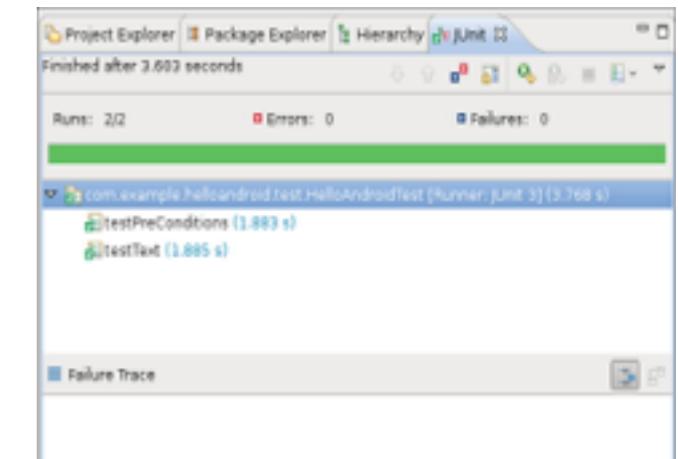
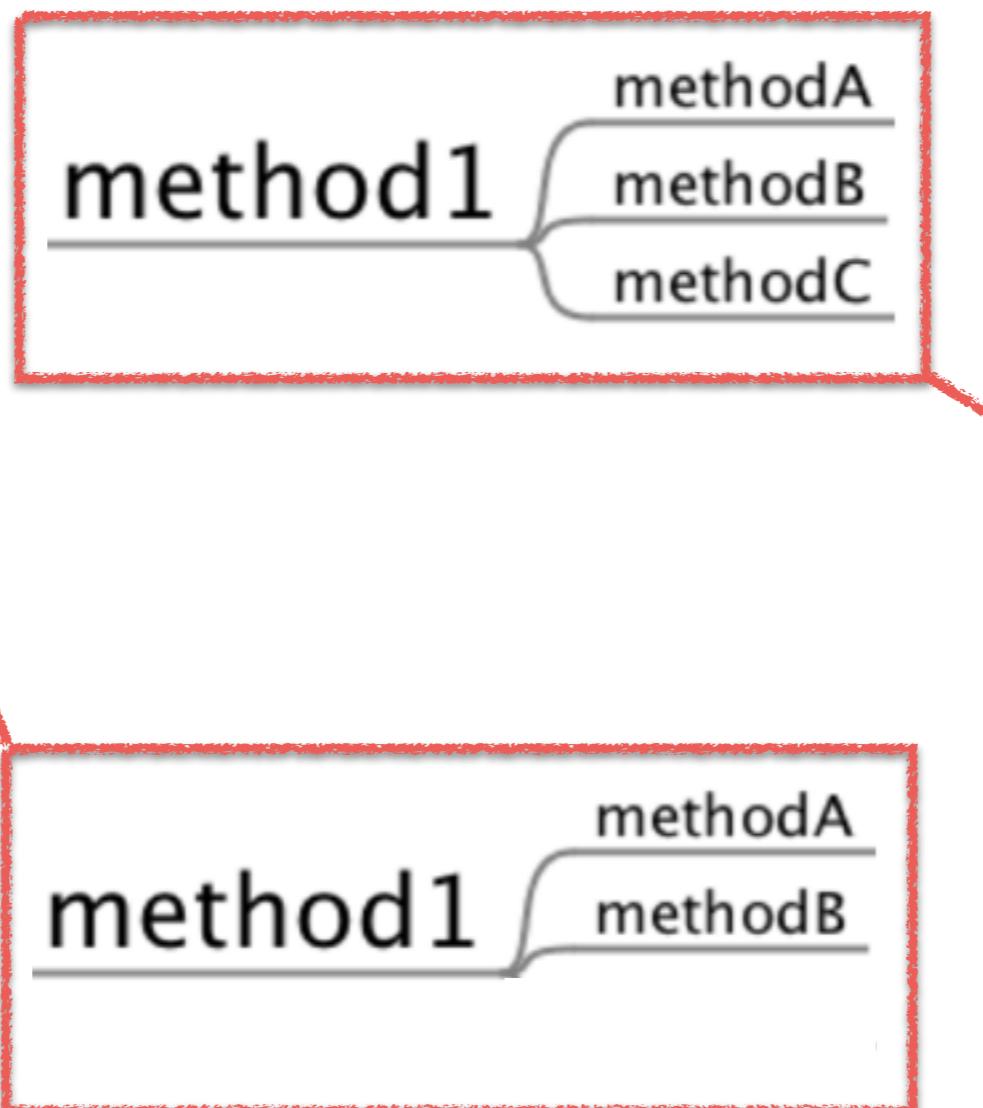
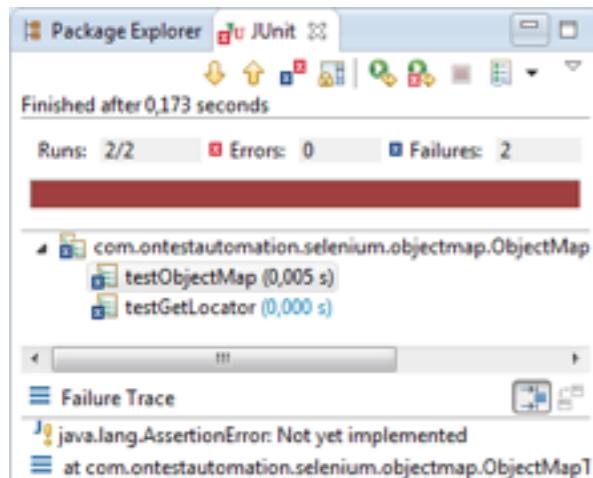


```
method1() {  
    methodA()  
    methodB()  
    if(condition) {  
        return  
    }  
    methodC()  
}
```



Raw Spectrum Analysis

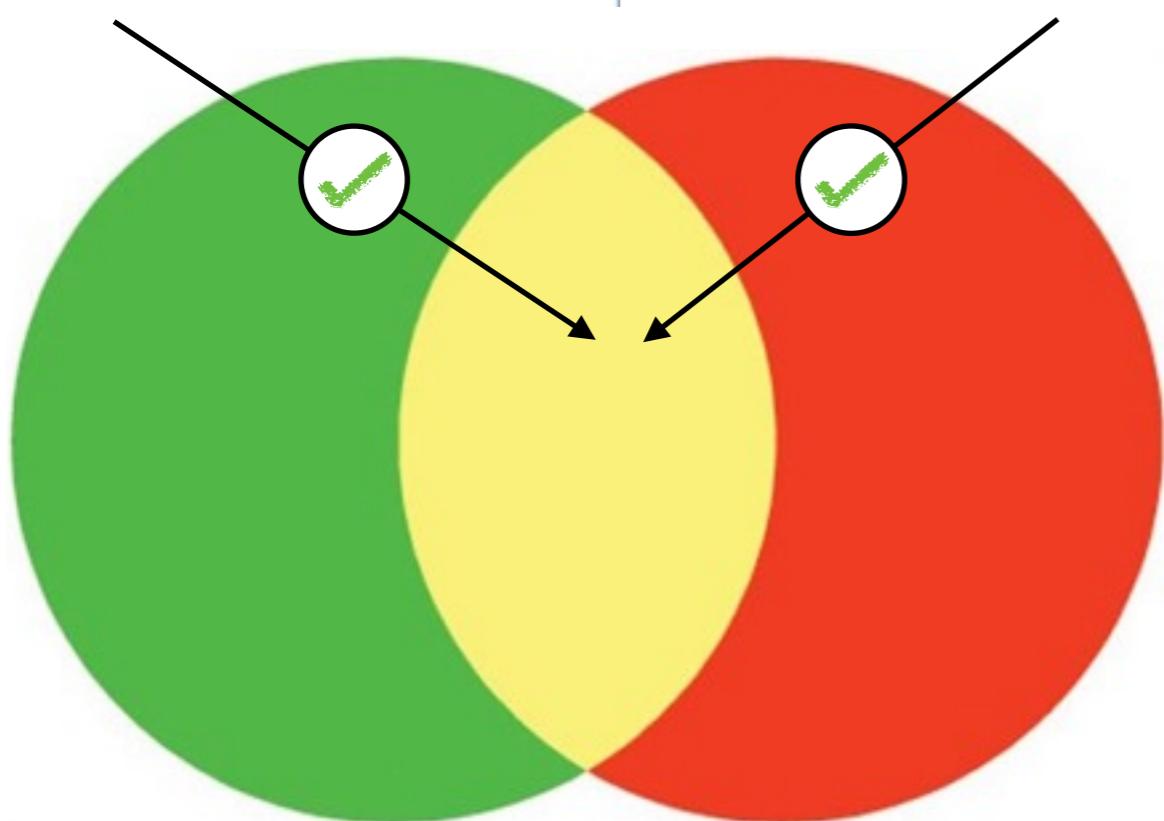
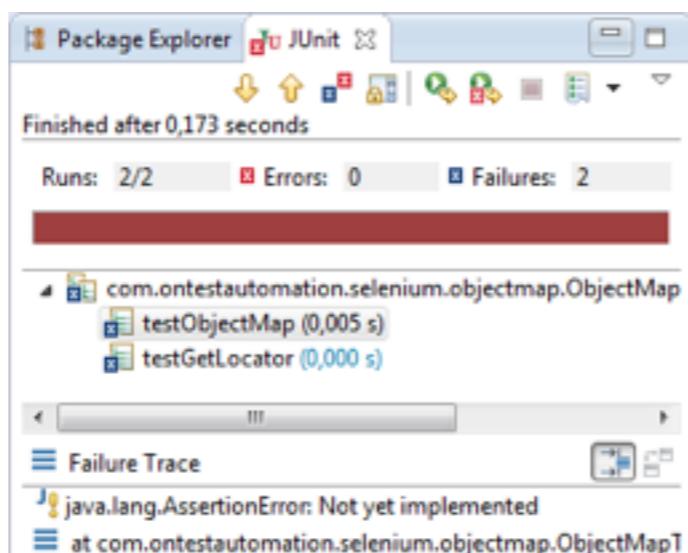
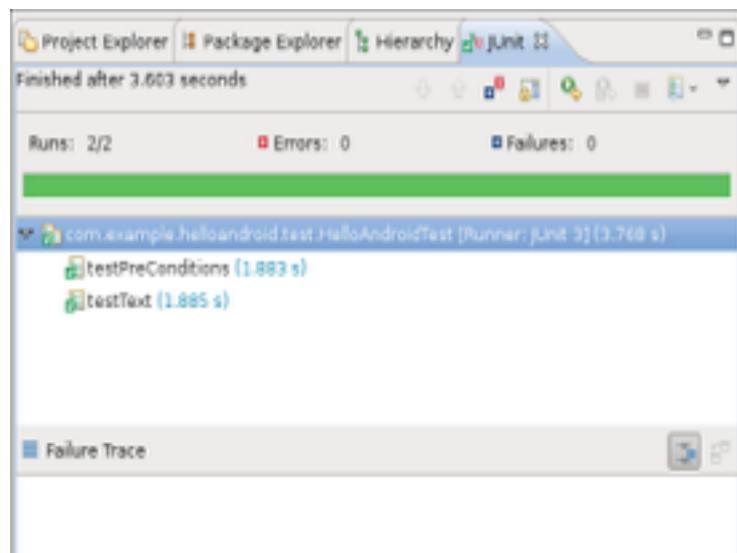
Missing



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    if (condition) {
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}
```

Raw Spectrum Analysis

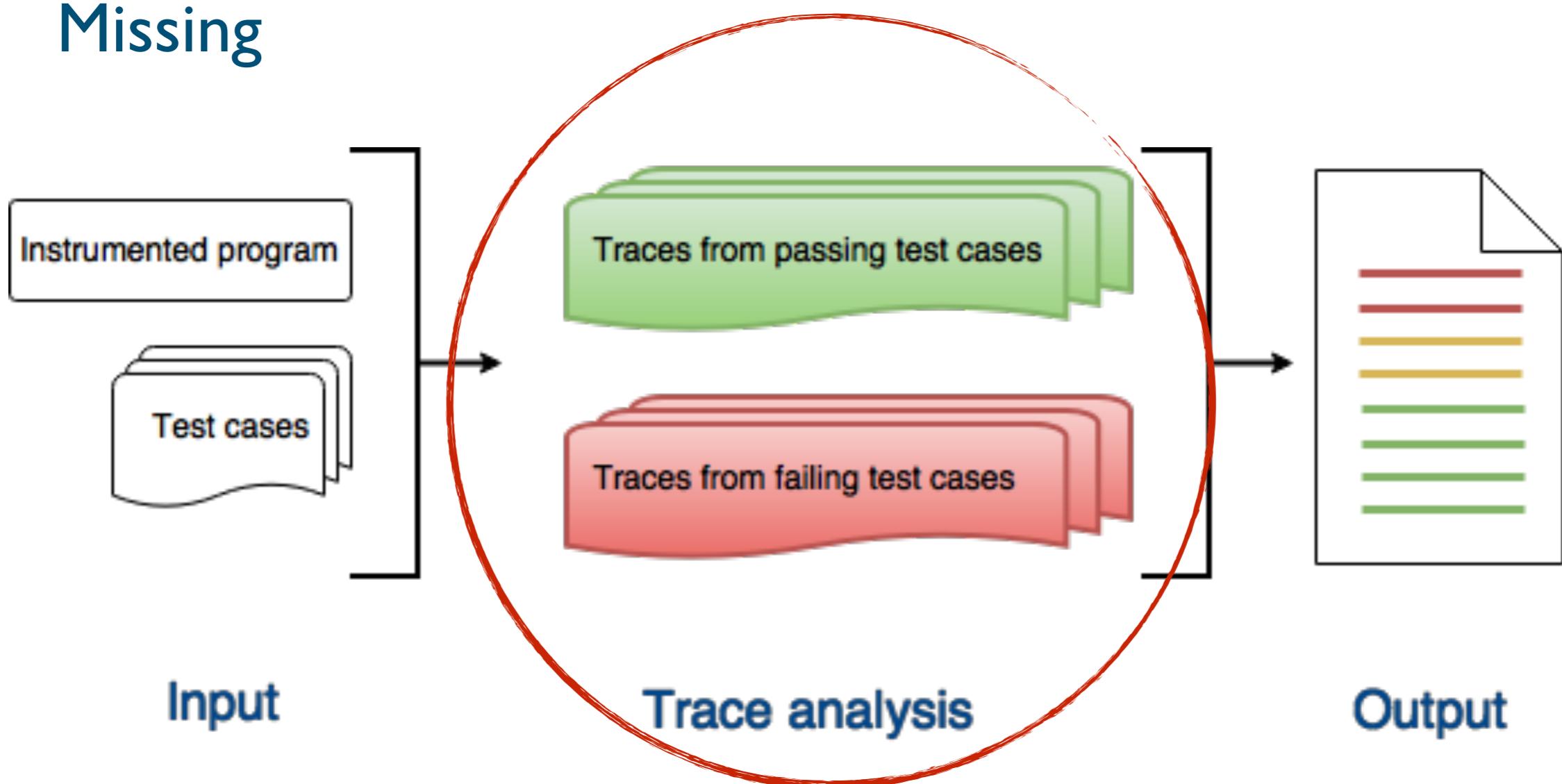
Missing



```
method1 () {  
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    if (condition) {  
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    methodC ()  
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```

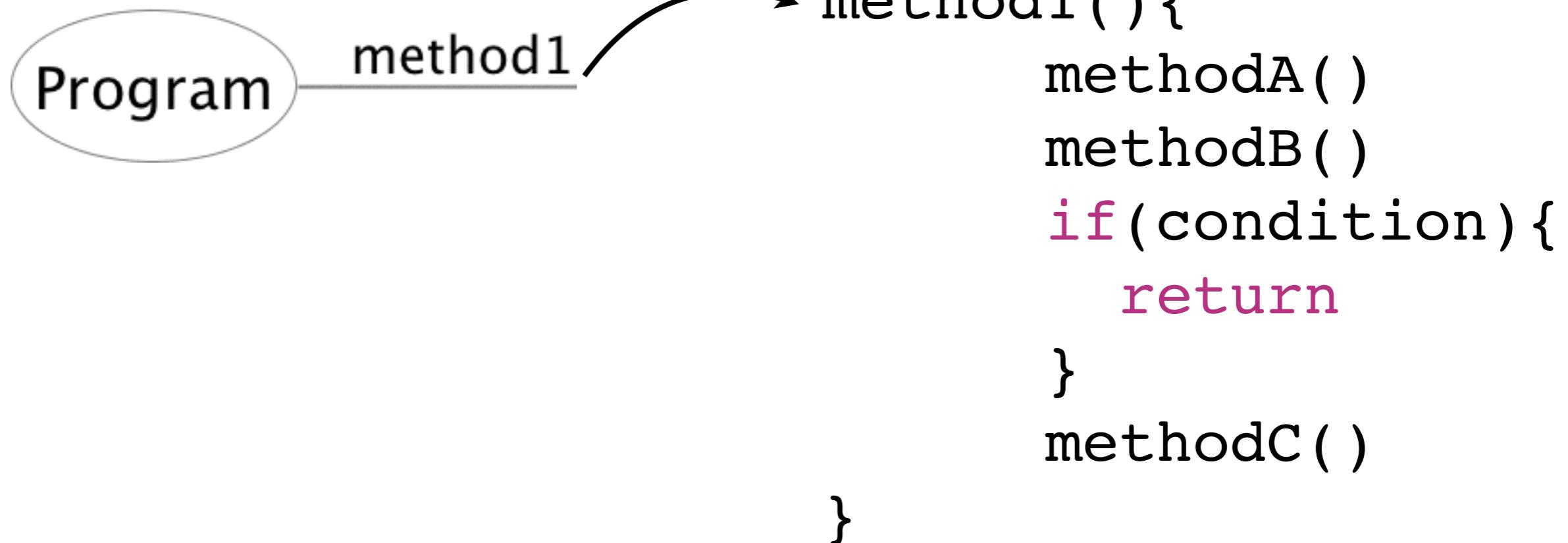
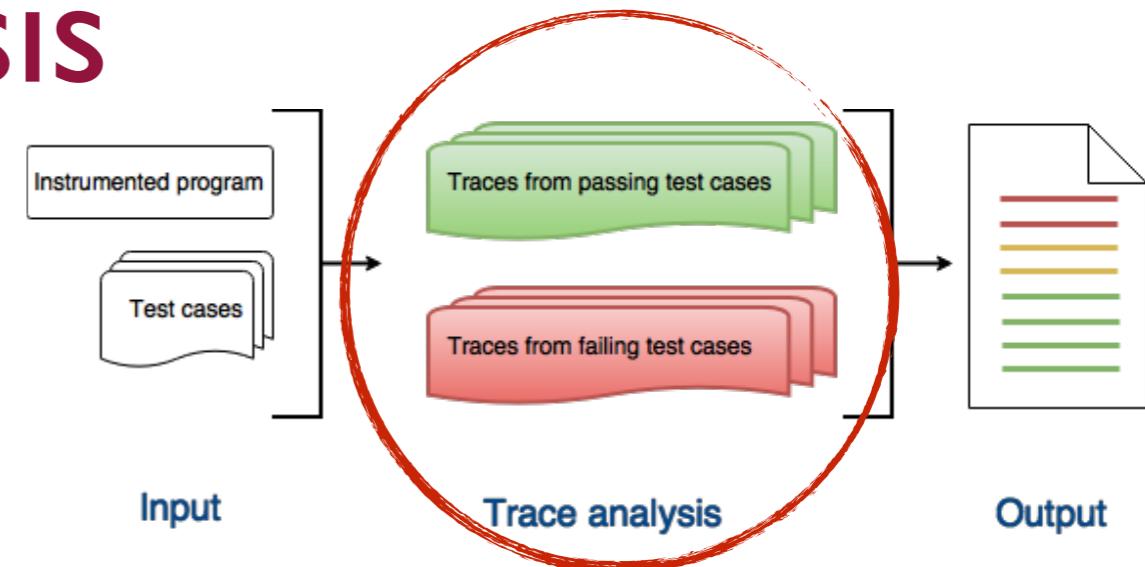
Raw Spectrum Analysis

Missing



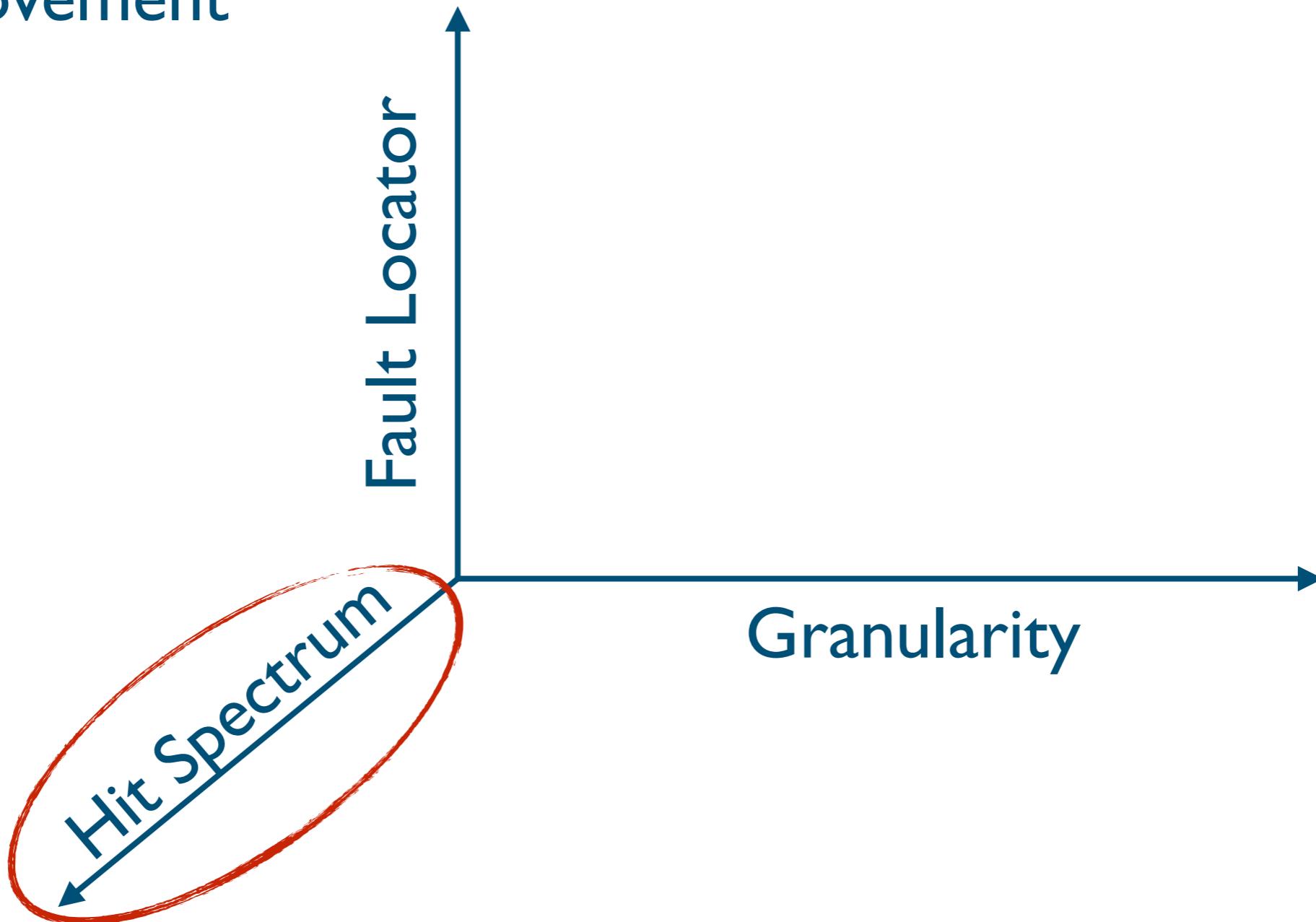
Raw Spectrum Analysis

Missing



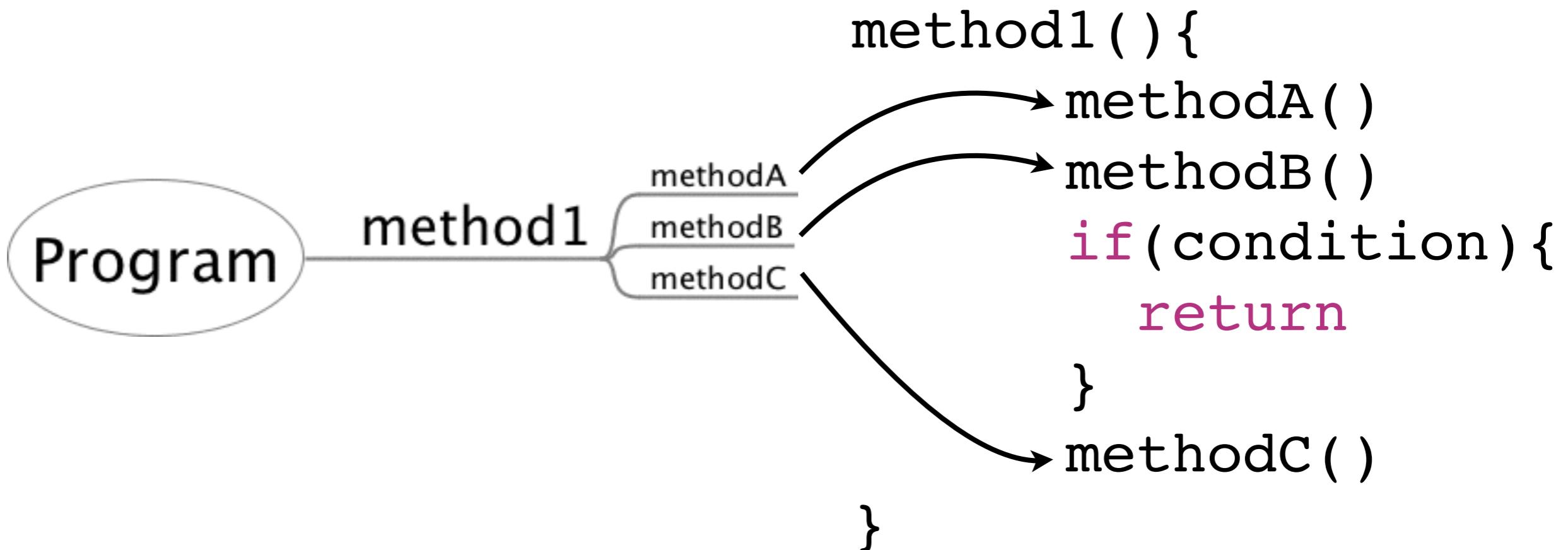
Raw Spectrum Analysis

Improvement



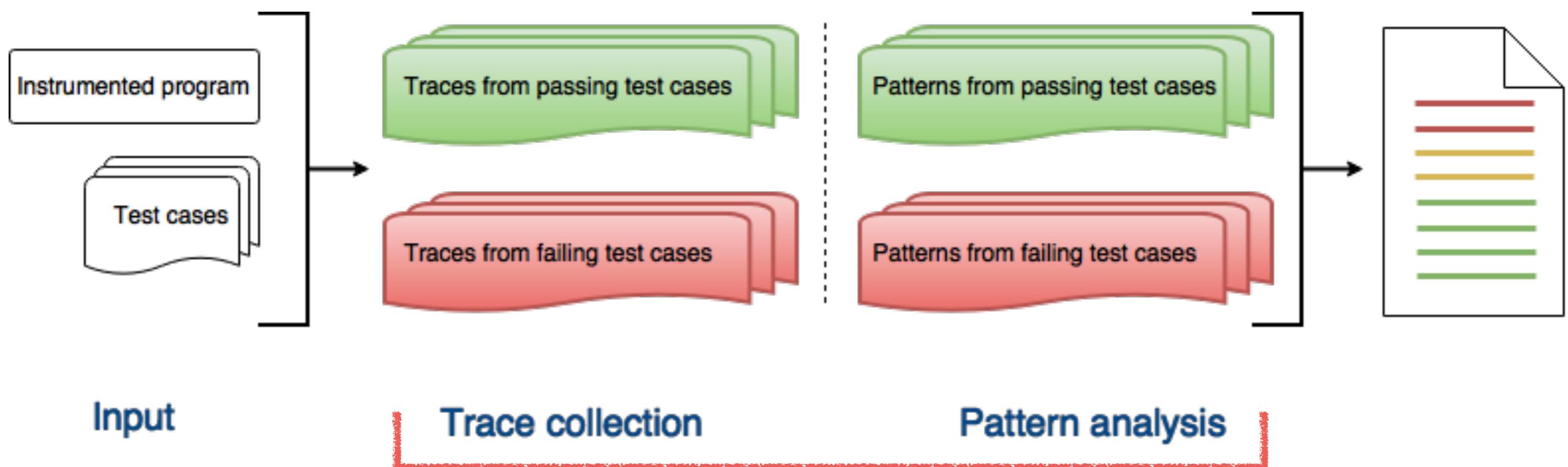
Raw Spectrum Analysis

Improvement



Raw Spectrum Analysis

Improvement

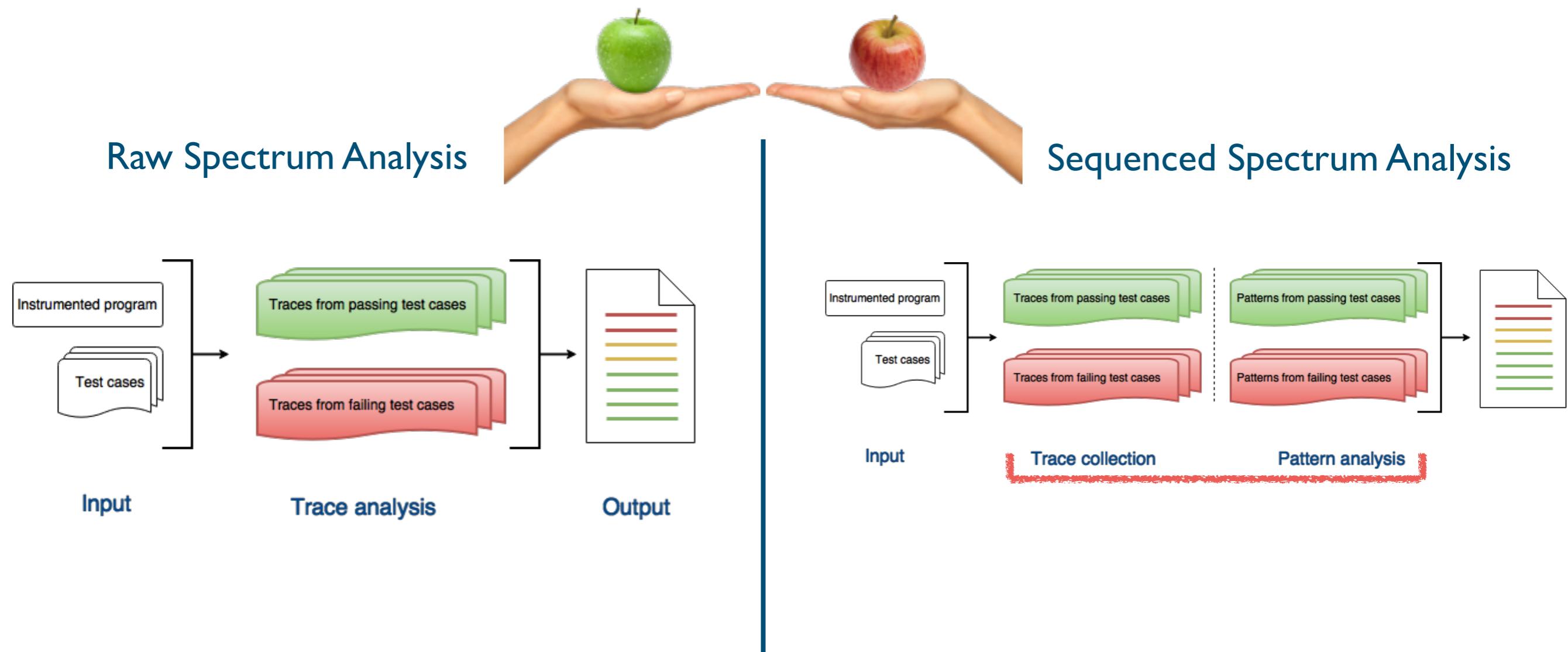


Sequenced Spectrum Analysis

Improvement



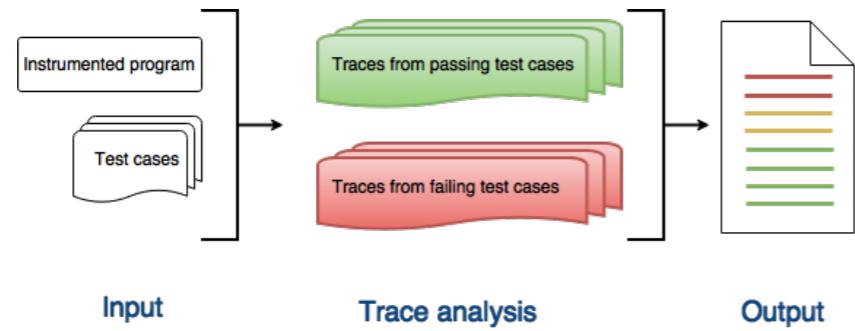
Case Study



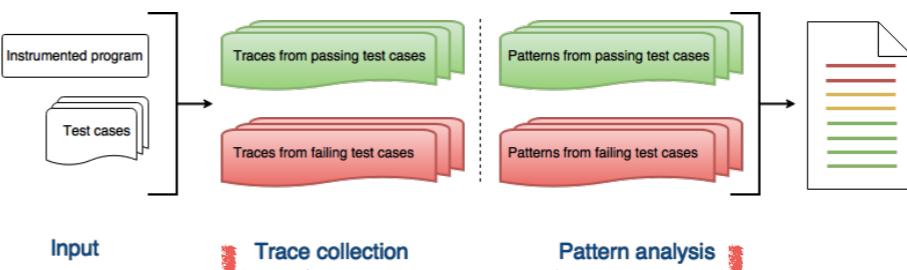
Case Study



Raw Spectrum Analysis



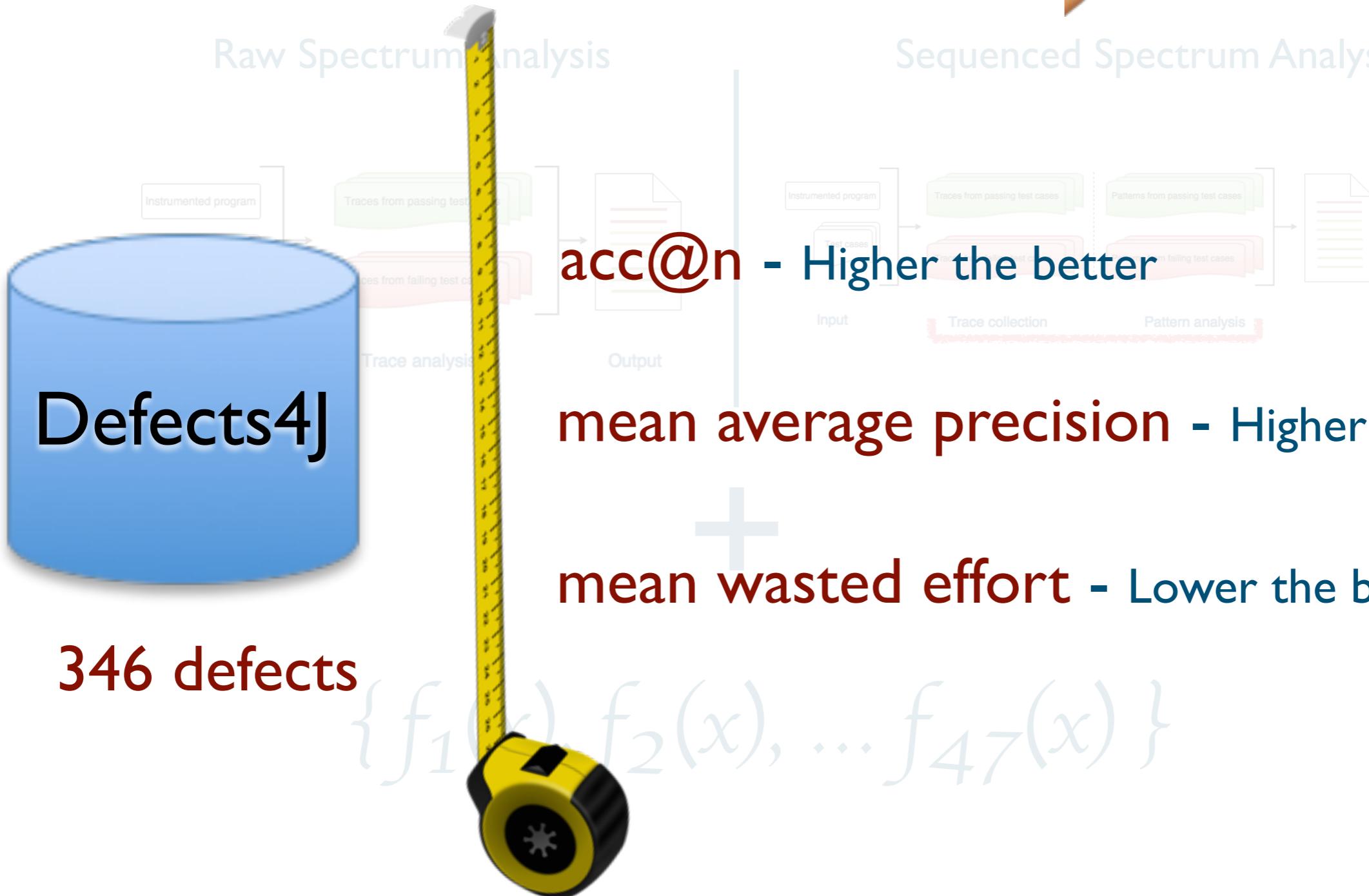
Sequenced Spectrum Analysis



+

$$\left\{ f_1(x), f_2(x), \dots, f_{47}(x) \right\}$$

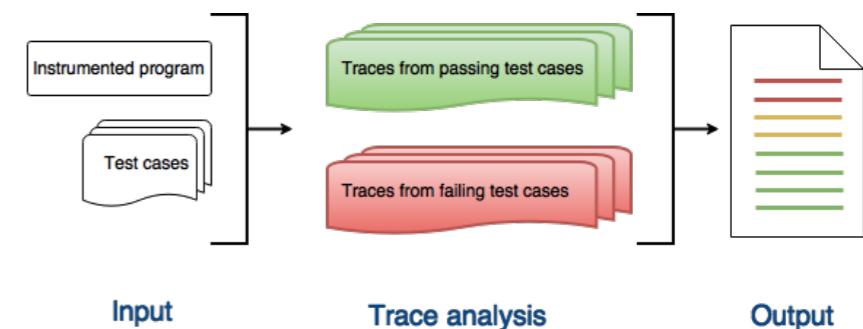
Case Study



Results

RQ1. What is the baseline performance of raw spectrum analysis?

Raw Spectrum Analysis



Rank	Fault Locator	acc@1	acc@3	acc@5	MAP	MWE
1	GP13	63	120	142	0.2780349	96.73
1	Naish2	63	120	142	0.2776756	96.64
2	M2	62	118	141	0.2753030	96.32
3	Goodman	61	116	138	0.2695181	16.68
3	Ample2	64	120	140	0.2764775	101.24
4	T*	62	119	139	0.2744910	96.37
5	Zoltar	61	118	138	0.2735461	96.14

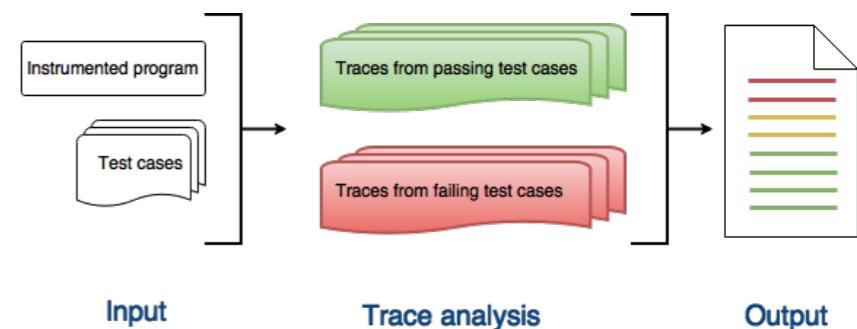
MAP = mean average precision

MWE = mean wasted effort

Results

RQ1. What is the baseline performance of raw spectrum analysis?

Raw Spectrum Analysis



Rank	Fault Locator	acc@1	acc@3	acc@5	MAP	MWE
1	GP13	63	120	142	0.2780349	96.73
1	Naish2	63	120	142	0.2776756	95.64
2						
3		18% exact hit			average non-faulty methods on top of the faulty method	
3	Ample2	64	120	140	0.2764775	101.24
4	T*	62	119	139	0.2744910	96.37
5	Zoltar	61	118	138	0.2735461	96.14

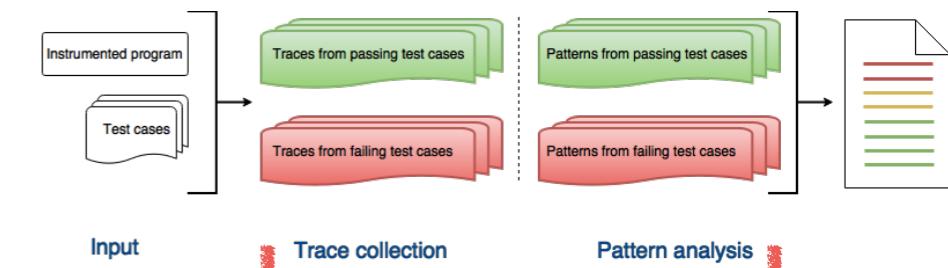
MAP = mean average precision

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Results

RQ2. How much can sequenced spectrum analysis improve upon raw spectrum analysis?

Sequenced Spectrum Analysis



Rank	Fault Locator	acc@1	acc@3	acc@5	MAP	MWE
1	Ample2	103	159	191	0.3925699	25.88
2	Fleiss	103	157	191	0.3874628	16.01
3	T*	102	160	190	0.3936098	31.18
4	M2	102	160	189	0.3933028	31.10
5	Arithmetic Mean	103	157	189	0.3875244	26.67

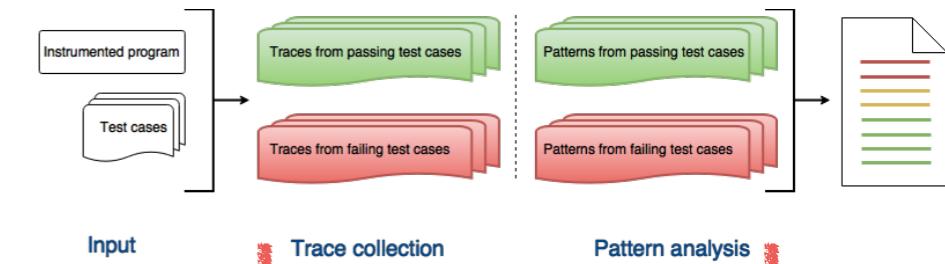
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1	Ample2	103	159	191	0.3925699	25.88
2	Fleiss	103	157	191	0.3874628	10.01
3	T*	30% exact hit			average non-faulty methods on top of the faulty method	
4	M2	102	160	189	0.3933028	31.10
5	Arithmetic Mean	103	157	189	0.3875244	26.67

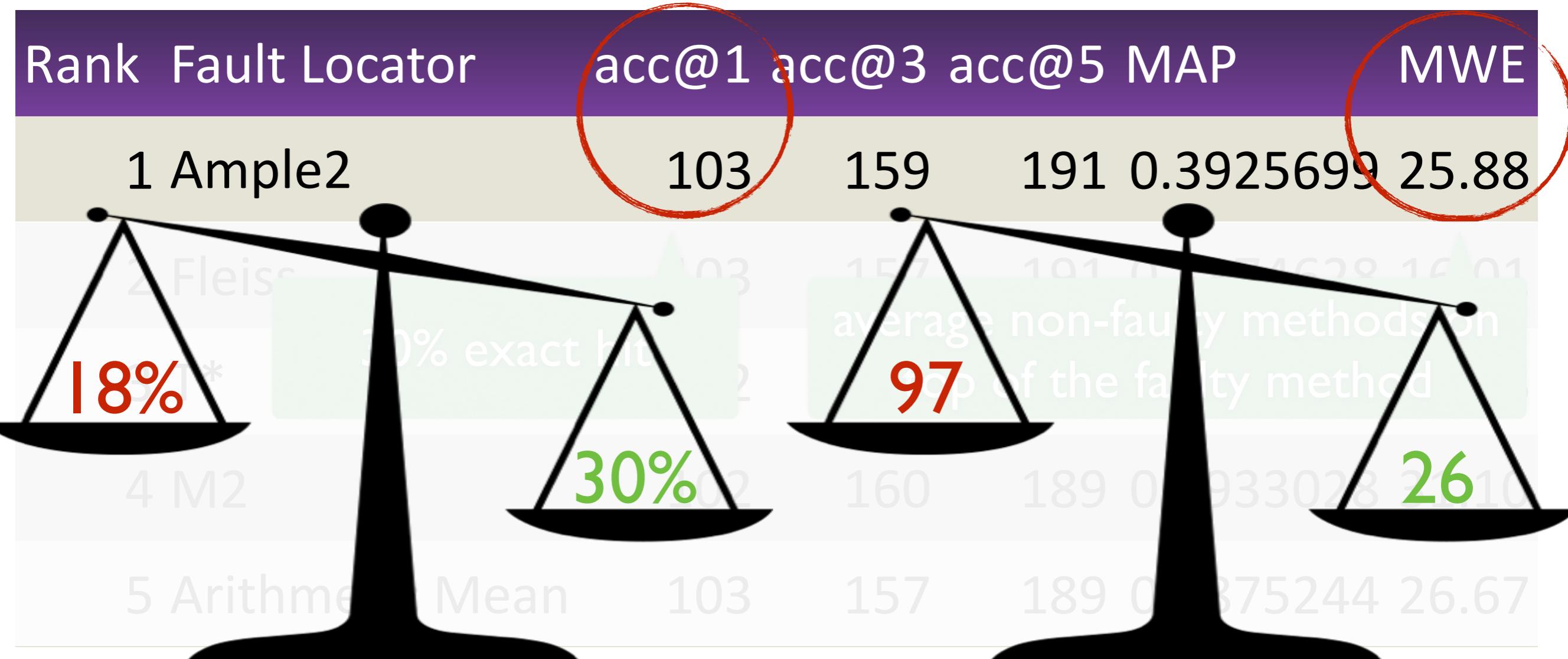
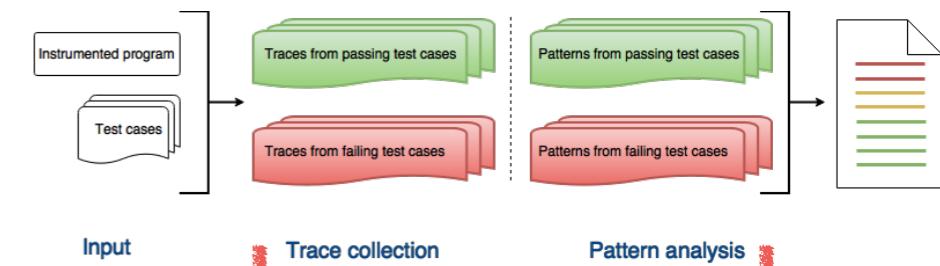
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Sequenced Spectrum Analysis

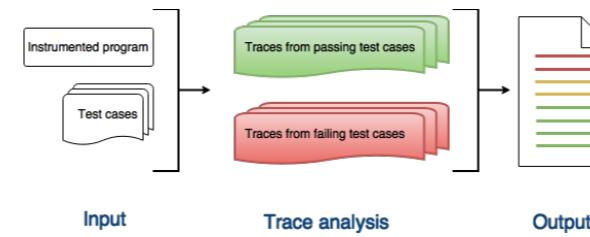


MAP = mean average precision

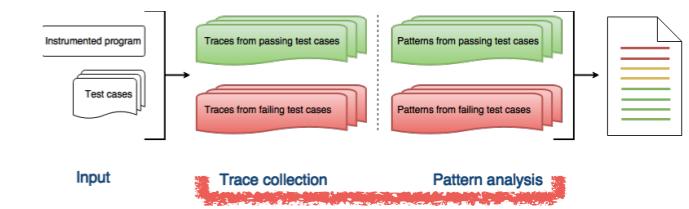
MWE = mean wasted effort

Results

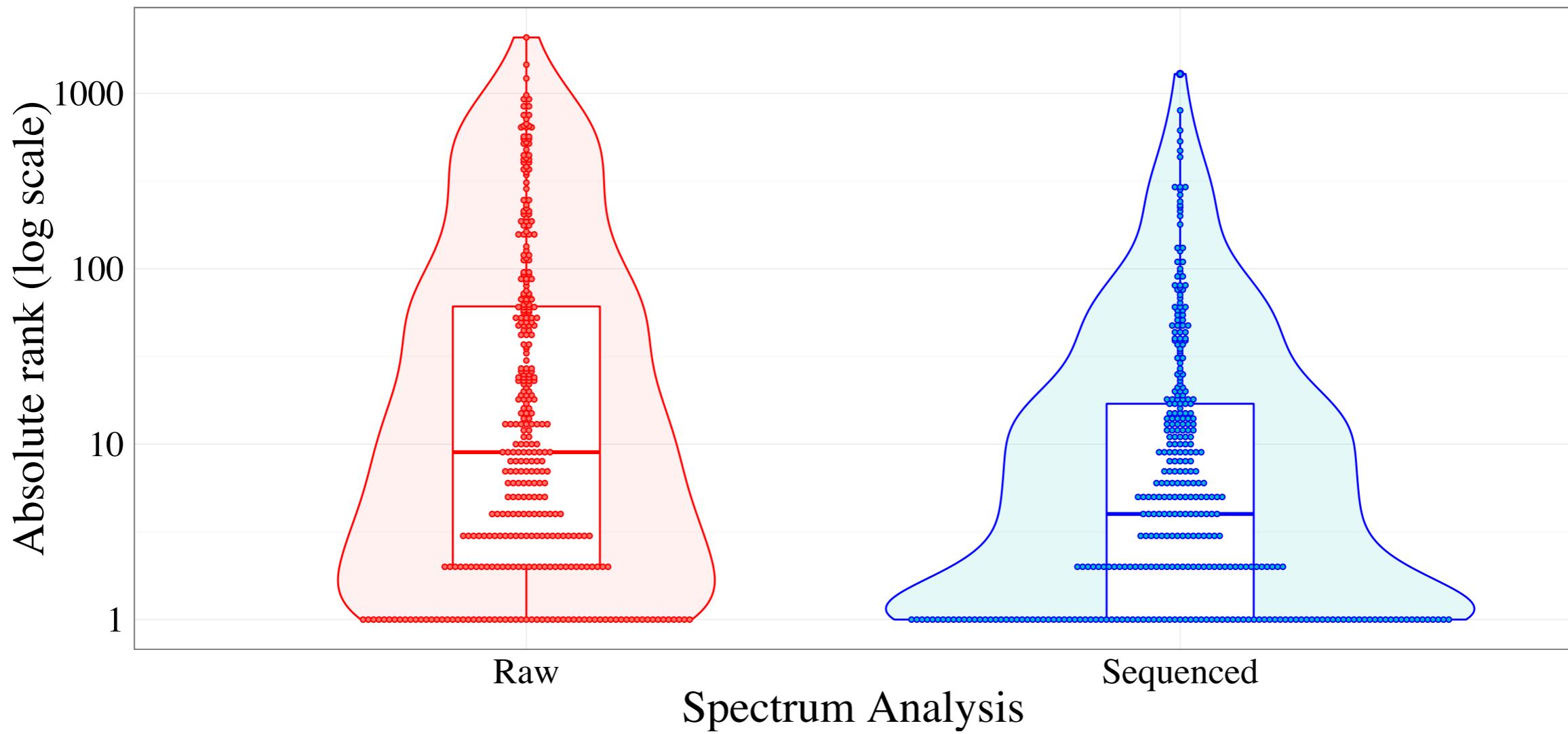
Raw Spectrum Analysis



Sequenced Spectrum Analysis

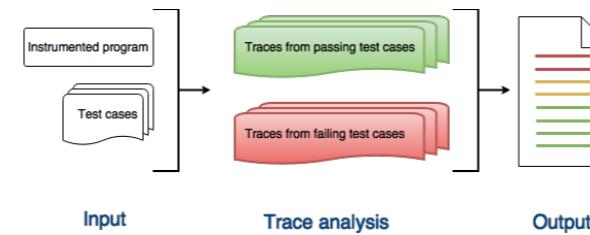


Spectrum Analysis: Raw Spectrum Analysis Sequenced Spectrum Analysis

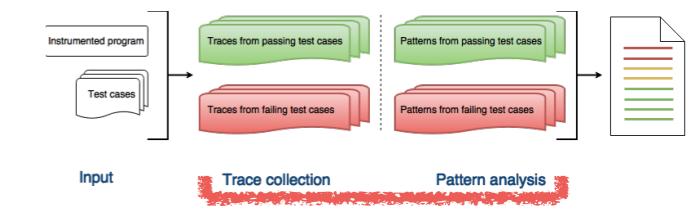


Results

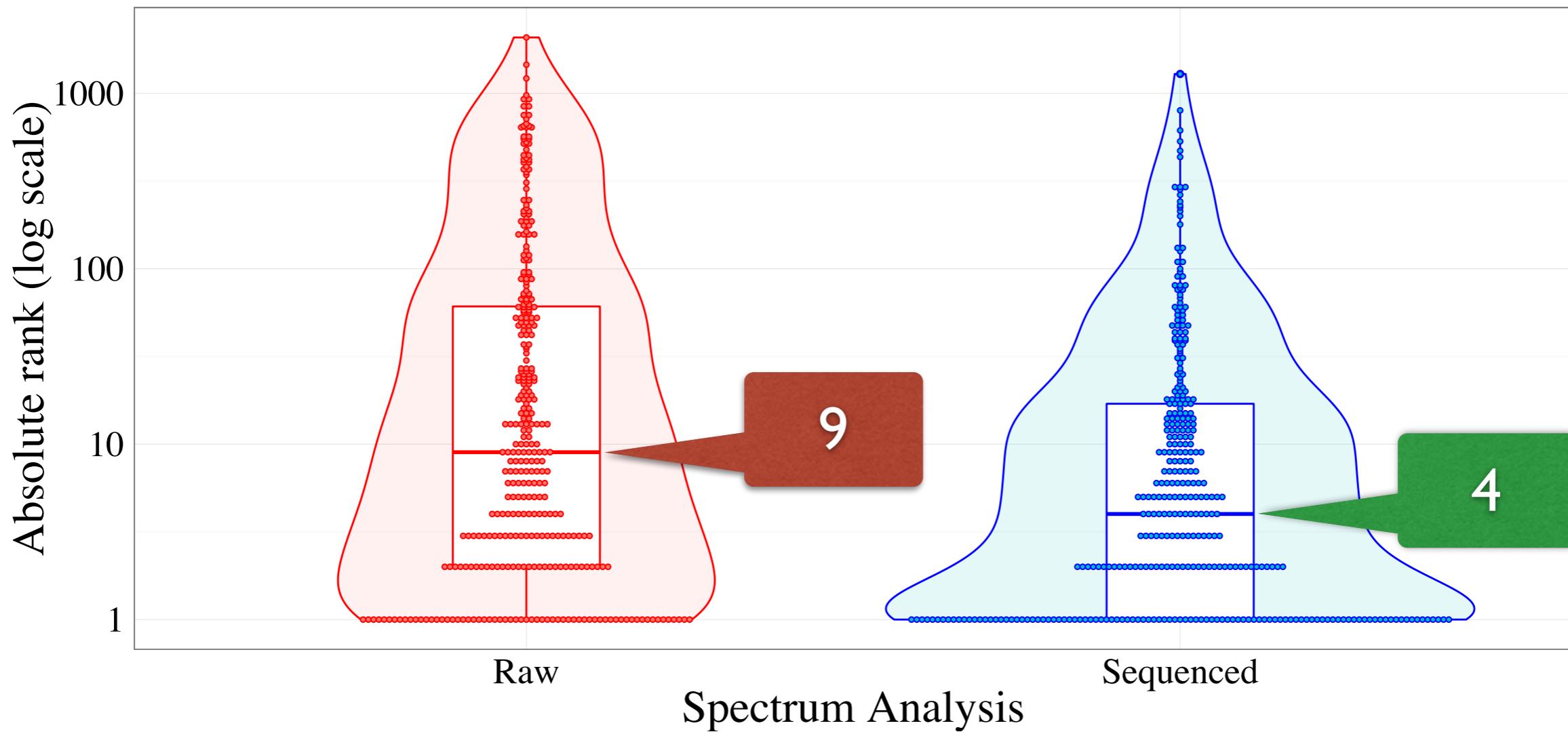
Raw Spectrum Analysis



Sequenced Spectrum Analysis

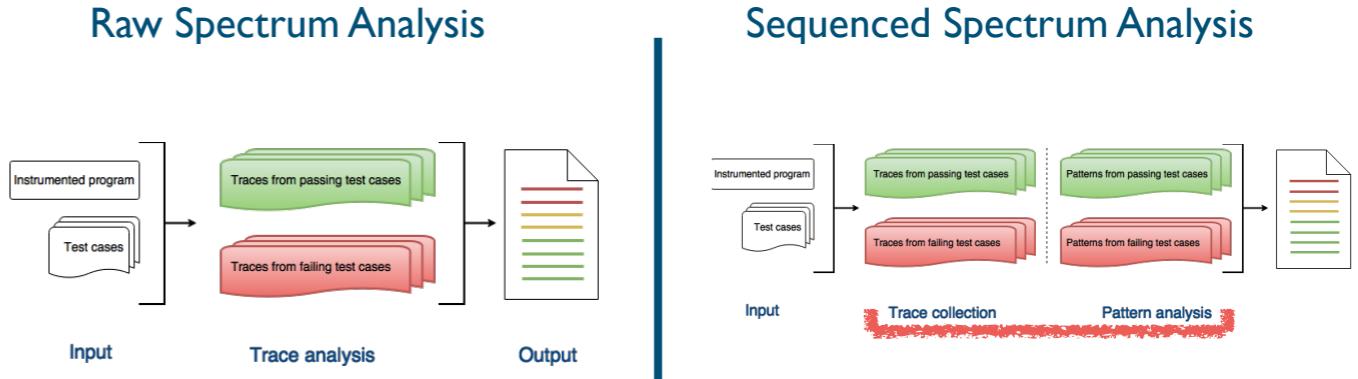


Spectrum Analysis: Raw Spectrum Analysis Sequenced Spectrum Analysis



Results

RQ3. Are there project specific differences between the rankings?



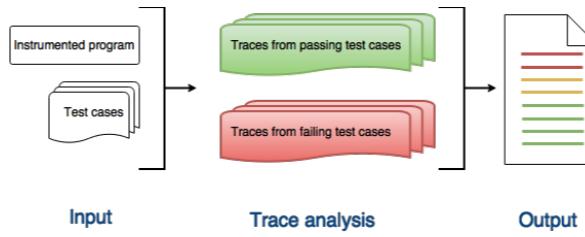
Top Fault Locators

Project	Sequenced	Raw
Closure	Fleiss	GP13
Math	Goodman	Goodman
Lang	Geometric Mean	GP13
Time	Ample2	GP13
Chart	CBISqrt	Tarantula

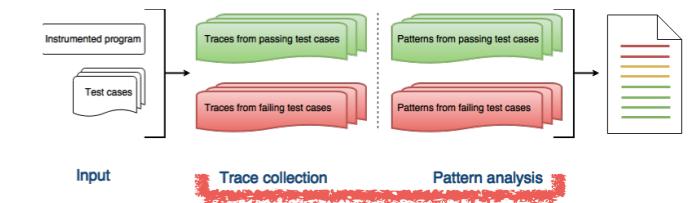
Results

RQ3. Are there project specific differences between the rankings?

Raw Spectrum Analysis



Sequenced Spectrum Analysis



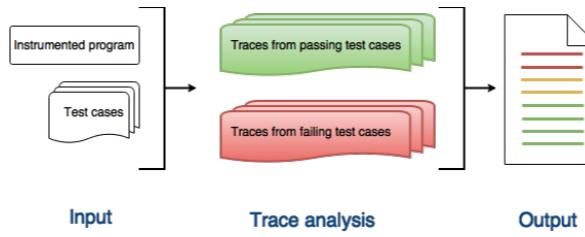
acc@1

Project	Sequenced	Raw
Closure	17 / 133	7 / 133
Math	33 / 106	21 / 106
Lang	41 / 65	21 / 65
Time	6 / 27	5 / 27
Chart	9 / 26	10 / 26

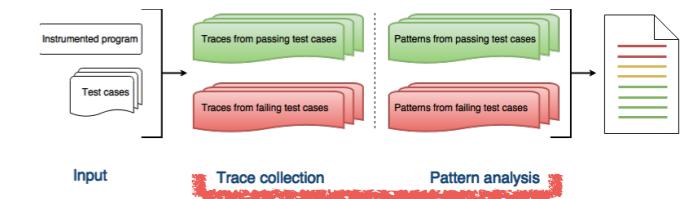
Results

RQ3. Are there project specific differences between the rankings?

Raw Spectrum Analysis



Sequenced Spectrum Analysis



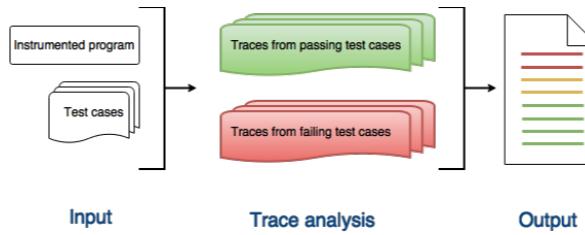
acc@I

Project	Sequenced	Raw
Closure	17 / 133	7 / 133
Math	33 / 106	21 / 106
Lang	41 / 65	21 / 65
Time	6 / 27	5 / 27
Chart	9 / 26	10 / 26

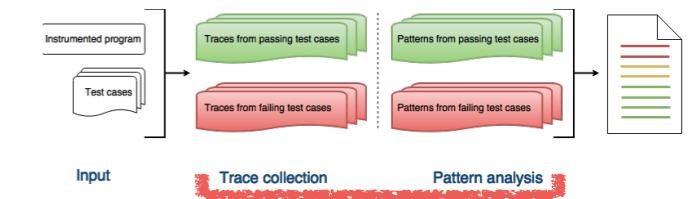
Results

RQ3. Are there project specific differences between the rankings?

Raw Spectrum Analysis



Sequenced Spectrum Analysis



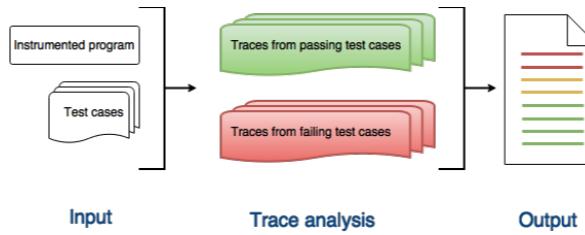
Mean Wasted Effort

Project	Sequenced	Raw
Closure	31	223
Math	5	8
Lang	1	4
Time	16	39
Chart	13	27

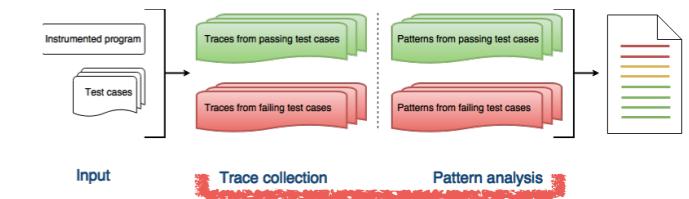
Results

RQ3. Are there project specific differences between the rankings?

Raw Spectrum Analysis



Sequenced Spectrum Analysis



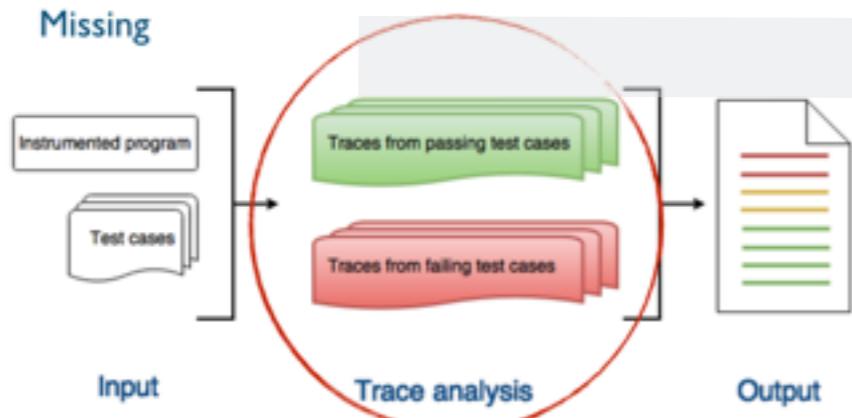
Mean Wasted Effort

Project	Sequenced	Raw
Closure	31	223
Math	5	8
Lang	1	4
Time	16	39
Chart	13	27

Summary

Raw Spectrum Analysis

Missing



Sequenced Spectrum Analysis

Improvement



Case Study

Raw Spectrum Analysis



Sequenced Spectrum Analysis

+

$$\{f_1(x), f_2(x), \dots, f_{47}(x)\}$$

Results



Spectrum Analysis: ■ Raw Spectrum Analysis ■ Sequenced Spectrum Analysis

