Improving Failure Prediction Methods by Fault Injection

IFIP
WG 10.4

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Why do computers fail?

"As far as we can tell, the system went down because someone stepped on a crack in the sidewalk."

Too many reasons…

- Hardware problems

Too many reasons…

- Environment problems

Too many reasons…

- Bad configuration

Too many reasons…

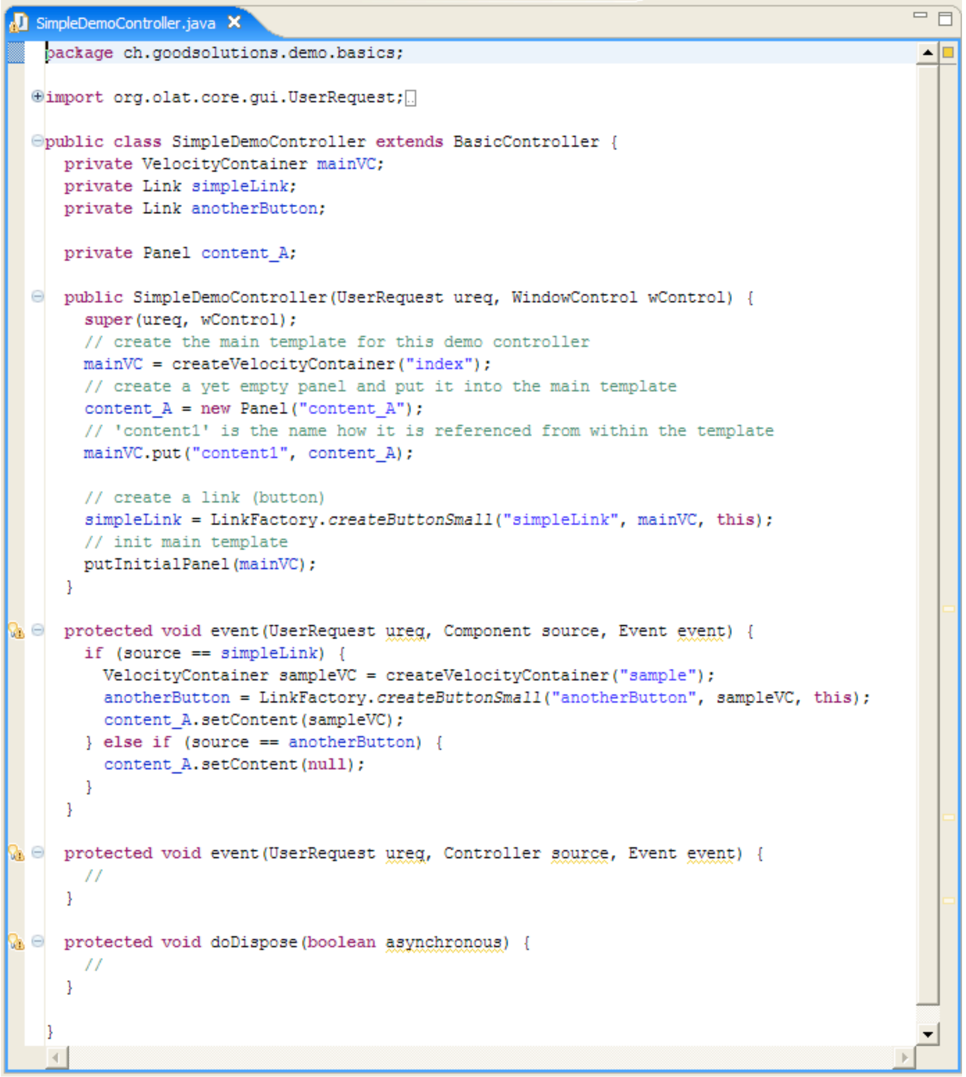
- Misuse

Too many reasons…

- Not proven design

But most of the times it is due to…

- Software faults



```java
package ch.goodsolutions.demo.basics;

import org.olat.core.gui.UserRequest;

public class SimpleDemoController extends BasicController {
  private VelocityContainer mainVC;
  private Link simpleLink;
  private Link anotherButton;

  private Panel content_A;

  public SimpleDemoController(UserRequest ureq, WindowControl wControl) {
    super(ureq, wControl);
    // create the main template for this demo controller
    mainVC = createVelocityContainer("index");
    // create a yet empty panel and put it into the main template
    content_A = new Panel("content_A");
    // 'content1' is the name how it is referenced from within the template
    mainVC.put("content1", content_A);

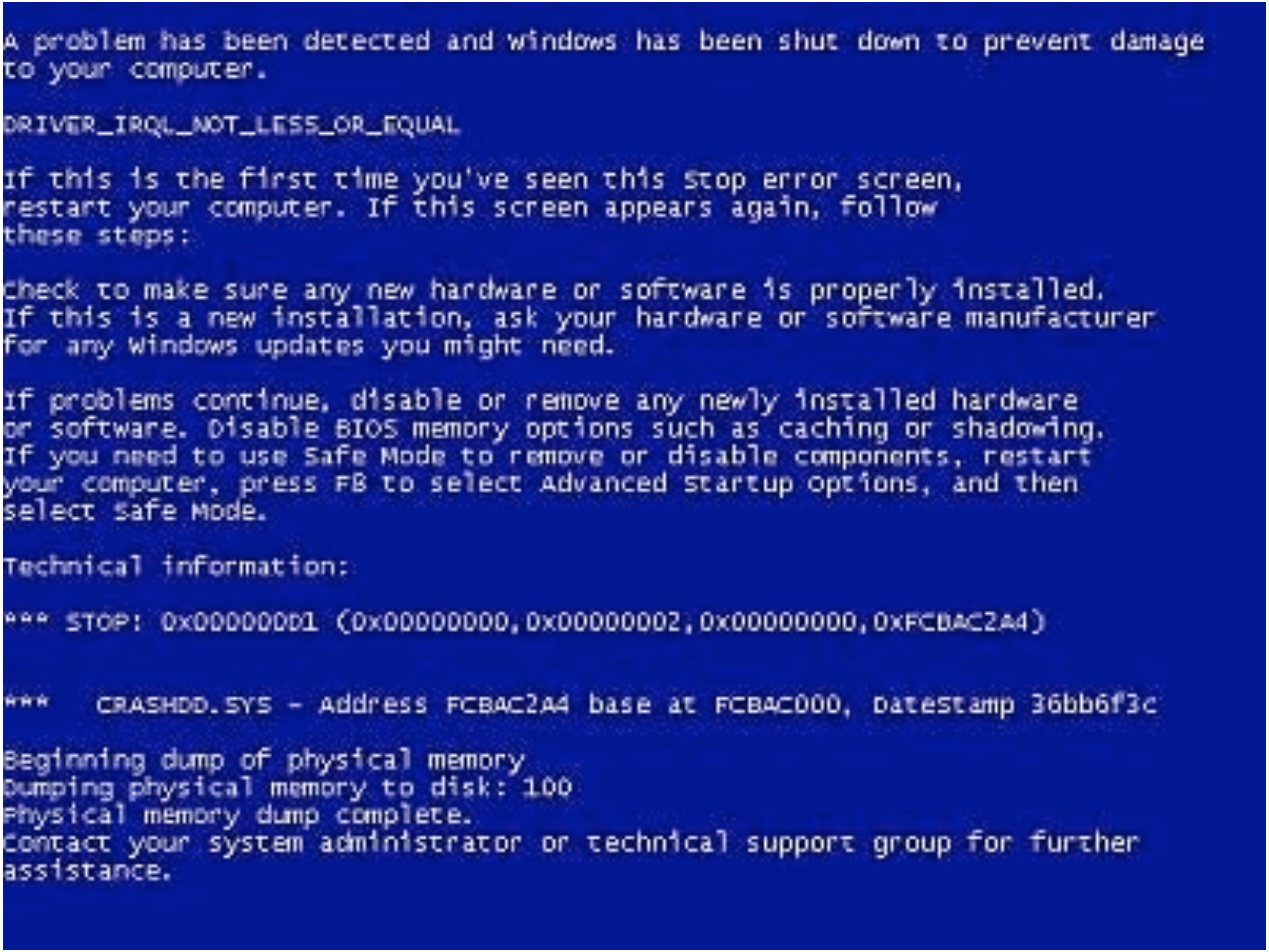
    // create a link (button)
    simpleLink = LinkFactory.createButtonSmall("simpleLink", mainVC, this);
    // init main template
    putInitialPanel(mainVC);
  }

  protected void event(UserRequest ureq, Component source, Event event) {
    if (source == simpleLink) {
      VelocityContainer sampleVC = createVelocityContainer("sample");
      anotherButton = LinkFactory.createButtonSmall("anotherButton", sampleVC, this);
      content_A.setContent(sampleVC);
    } else if (source == anotherButton) {
      content_A.setContent(null);
    }
  }

  protected void event(UserRequest ureq, Controller source, Event event) {
    //
  }

  protected void doDispose(boolean asynchronous) {
    //
  }

}
```



```
A problem has been detected and windows has been shut down to prevent damage
to your computer.

DRIVER_IRQL_NOT_LESS_OR_EQUAL

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restart your computer. If this screen appears again, follow
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Technical information:

*** STOP: 0x000000D1 (0x00000000,0x00000002,0x00000000,0xFCBAC2A4)


***   CRASHDD.SYS - Address FCBAC2A4 base at FCBAC000, DateStamp 36bb6f3c

Beginning dump of physical memory
Dumping physical memory to disk: 100
Physical memory dump complete.
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assistance.
```

What can we do?

- Don’t use computers ☺
  - Sooner or later they will fail!
- Now seriously:
  - Built better software
    - Many tried… most have failed ☺
  - Find ways to identify failure-prone situations
    - And react accordingly…
- But… how do we know when a failure is about to happen?

Predict!

But prediction is hard…

- Prophets do not exist!
- Failure prediction methods are complex
- Needs lots of data

- How to improve this?
  - That is the goal of our research…

Motivation

- Computer systems are growing in complexity
- Increasing complexity is seen as a major threat
- Software related failures are common

Operating System	SLOC (Million)
Windows NT 3.1	4-5
Windows NT 3.5	7-8
Windows NT 4.0	11-12
Windows 2000	more than 29
Windows XP	40
Windows Server 2003	50
OpenSolaris	9.7
FreeBSD	8.8
Mac OS X 10.4	86

What is failure prediction?

- The goal of online failure prediction is to identify failure-prone situations
  - i.e. situations that will probably evolve into a failure
- The output of online failure prediction can either be:
  - A decision that a failure is imminent or not
  - Some continuous measure evaluating the current situation as failure prone
- Short-term predictions are made on the basis of runtime monitoring

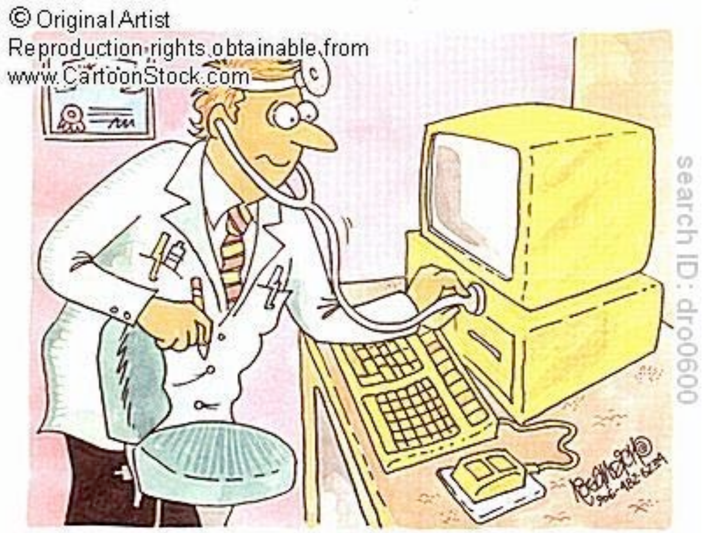
Using failure prediction

- Steps for building a high availability system based on failure prediction:

  1. **Observe**
  2. **Reason**
  3. **React**

Observe

- Develop methods that capture and select essential data of computer system
- Only a few of the many hundreds or even thousands of variables that could be observed actually may contribute to failure prediction
- How to select the relevant ones?



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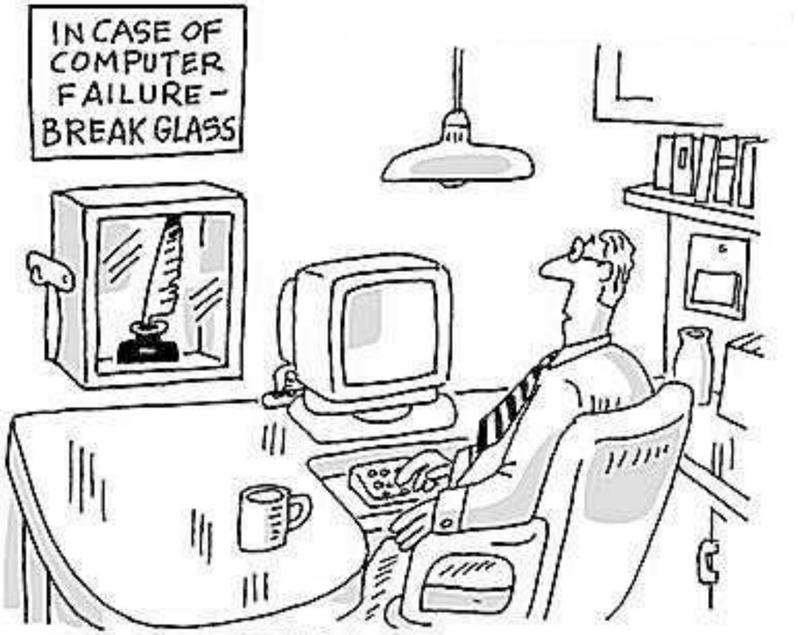
Reason

- Develop methods that interpret the data collected
- Recognize erroneous system states
- Predict future system states
- How to validate failure prediction methods?
- How to speedup the learning/training phase of failure prediction methods?
  - Using field data is not a good solution!

React

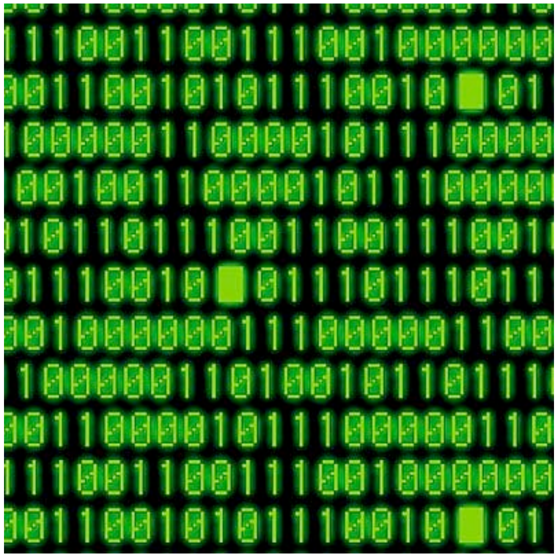
- Proactive recovery
- Failure avoidance schemes
- Built on the predictions and help to self-manage the system



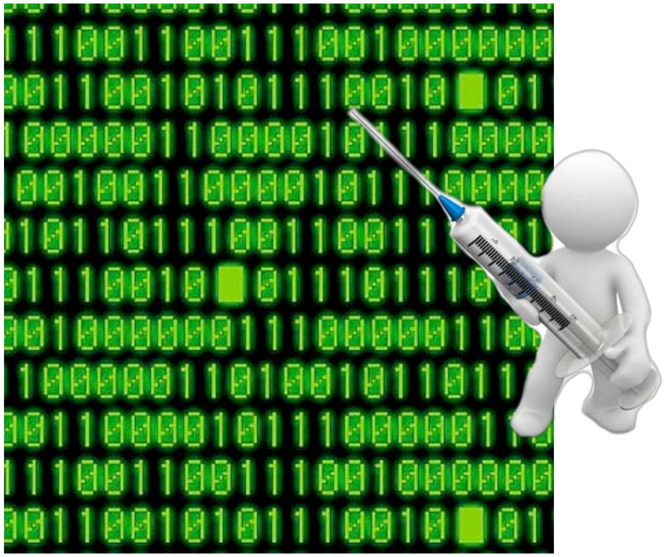
Our idea

Injection of realistic software faults to validate and improve failure prediction methods

Basic process



Basic process



Basic process

```
if ( a==3 && b==4 ) {
  do something
}

cmp dword ptr off_a[ebp],3
jne short ahead
cmp dword ptr off_b[ebp],4
jne short ahead
; ... do something ...
ahead:
...

; remaining prog. code
```

```
if ( a==3 && b==4 ) {
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cmp dword ptr off_a[ebp],3
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nop
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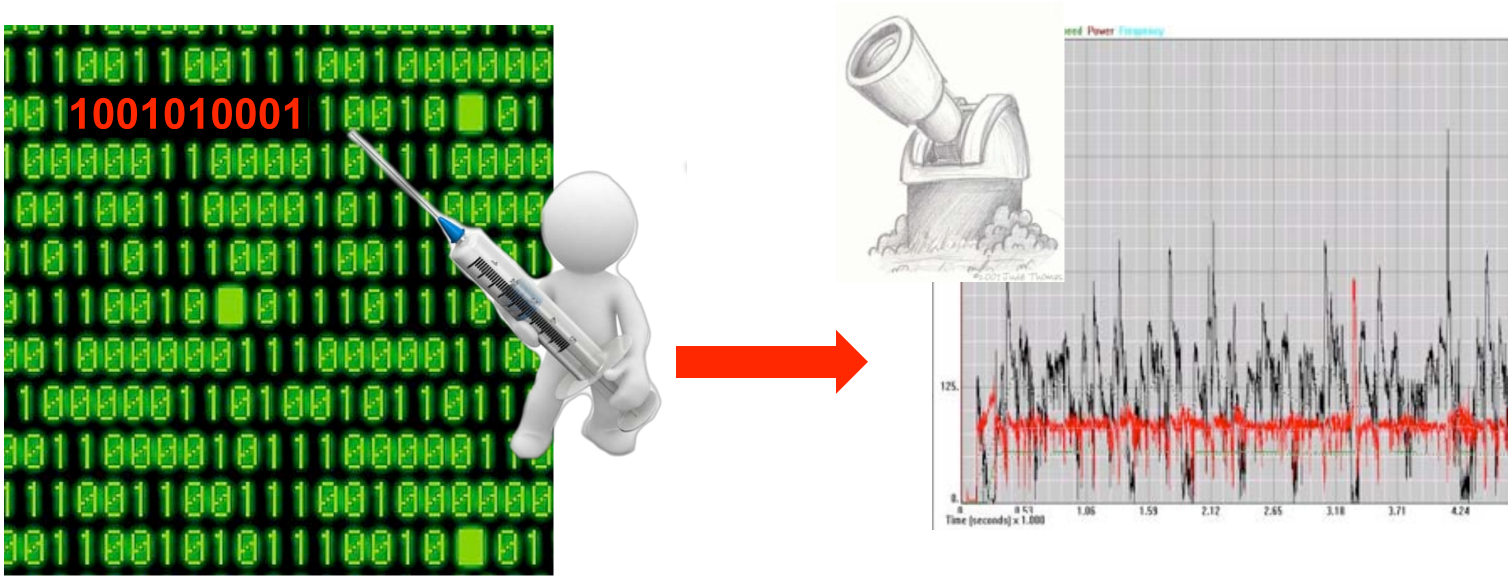

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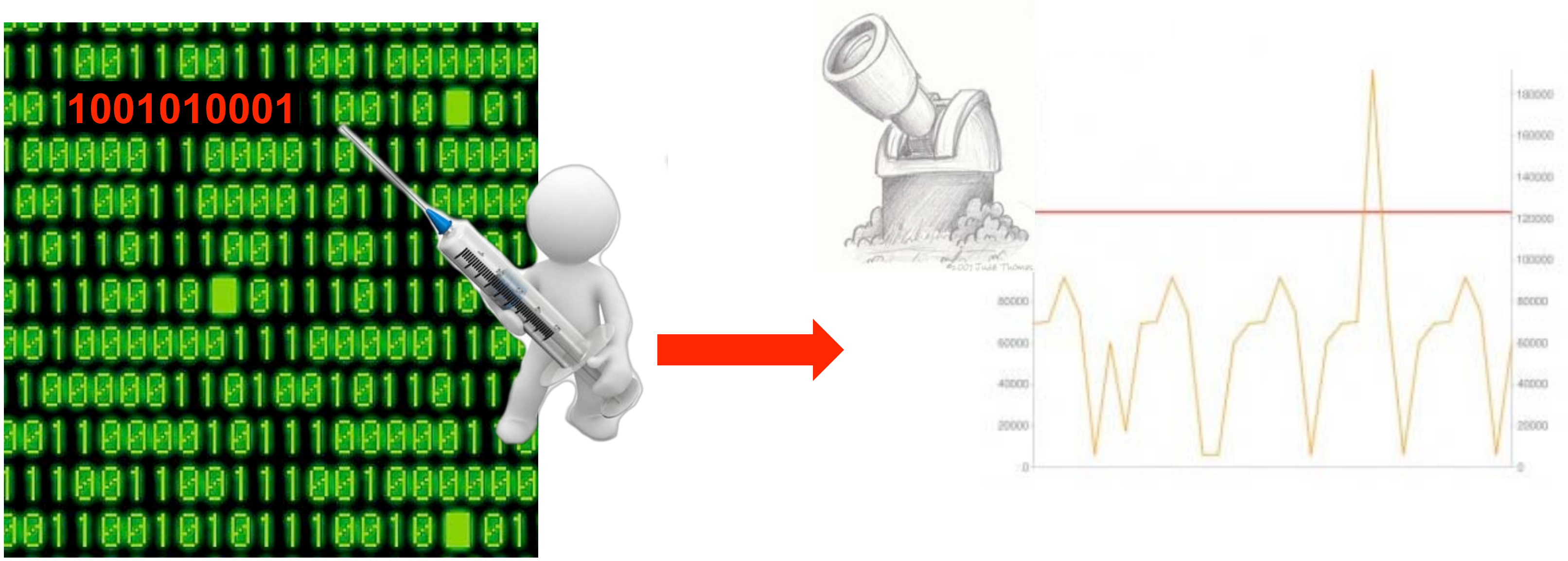

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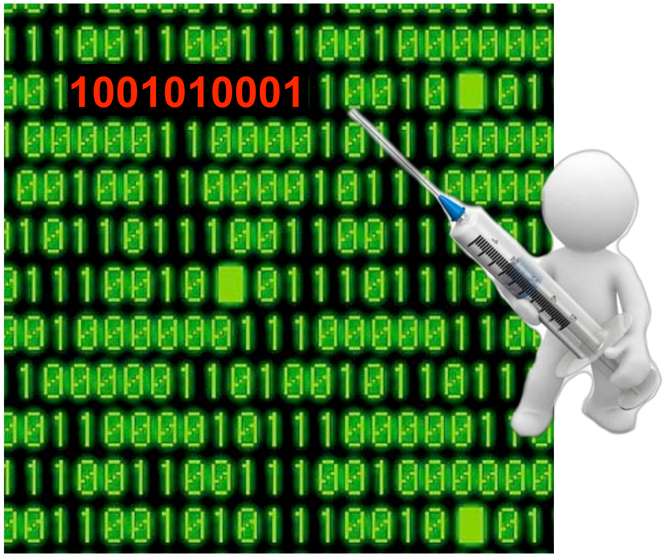

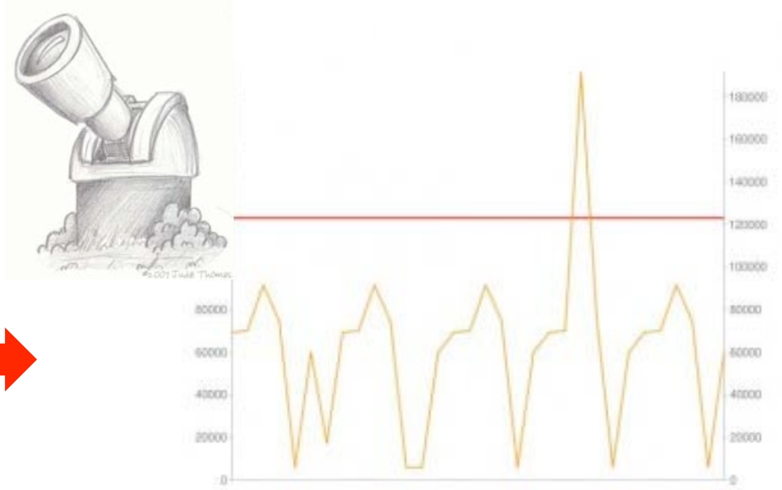

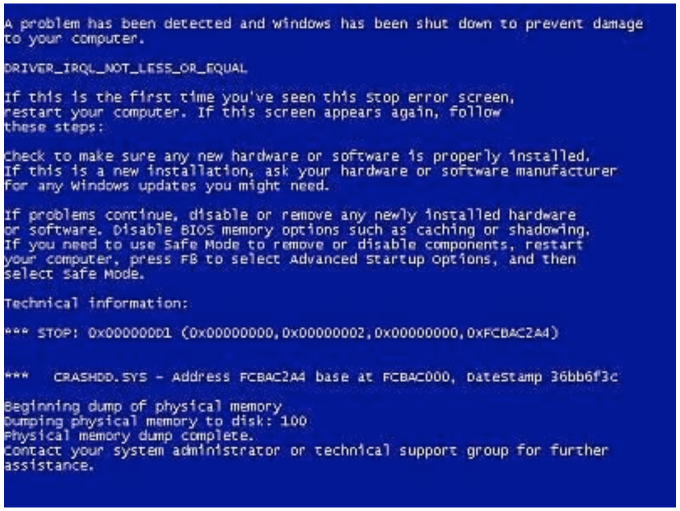

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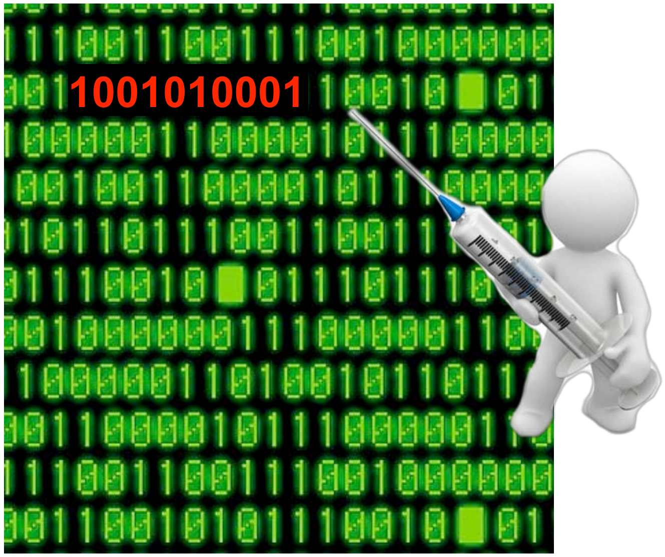

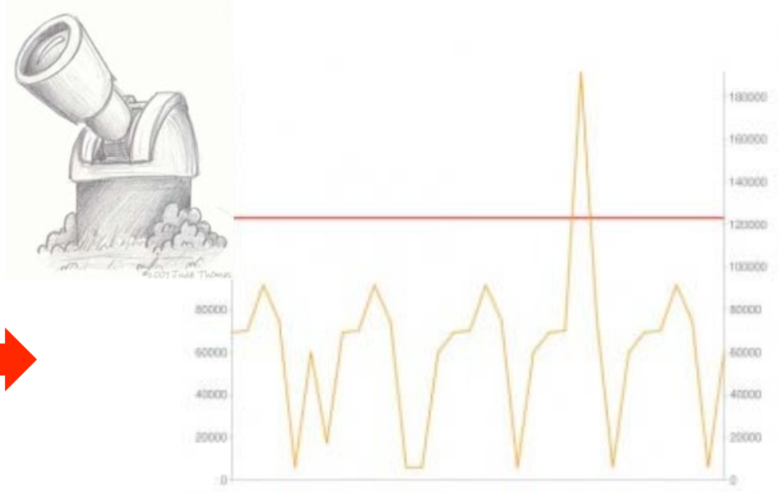

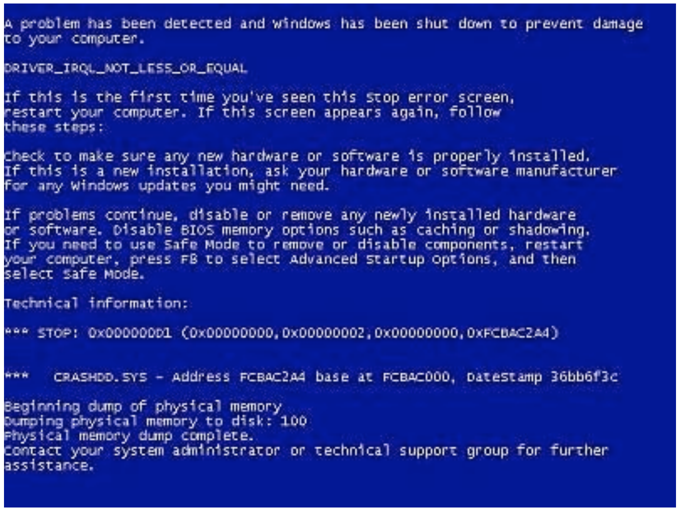

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Four scenarios

1. Help to identify the best symptoms for failure prediction

2. Accelerate the learning/training phase of prediction algorithms

3. Evaluate the figures of merit of prediction algorithms

4. Integrate fault injection in the prediction algorithm
   - As a form of continuous training process

Questions & Comments

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