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Model-based testing of NASA systems

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Problems in NASA projects

- Test cases are often developed manually
- Some test execution is automated (e.g., JUnit)
- Test cases miss valid “corner” cases
- Difficult to summarize what was tested

➢ Approach: Test Automation and Model-based Test Generation and Execution

➢ Supported by NASA’s SARP program

Motivation

- Software bugs can lead to deaths, injuries, or financial loss
- Software testing consumes 50% - 75% of the development effort
- Many NASA projects could benefit from test automation
- Demonstrated several times that regular testing is not enough (defects remain undetected)
  - and that MBT can detect several of these defects.

Currently Targeted Projects

- GMSEC – Reusable framework for ground systems
  - Modeled the Core API and Applications
  - Generated executable test cases from the model
  - Confirmed defects/violations reported and fixed
  - Test cases delivered to the team
- Core Flight Software – Reusable framework for flight systems
  - Modeled the OS abstraction layer (OSAL)
  - Generated executable test cases from the model
  - Confirmed defects/violations reported and fixed

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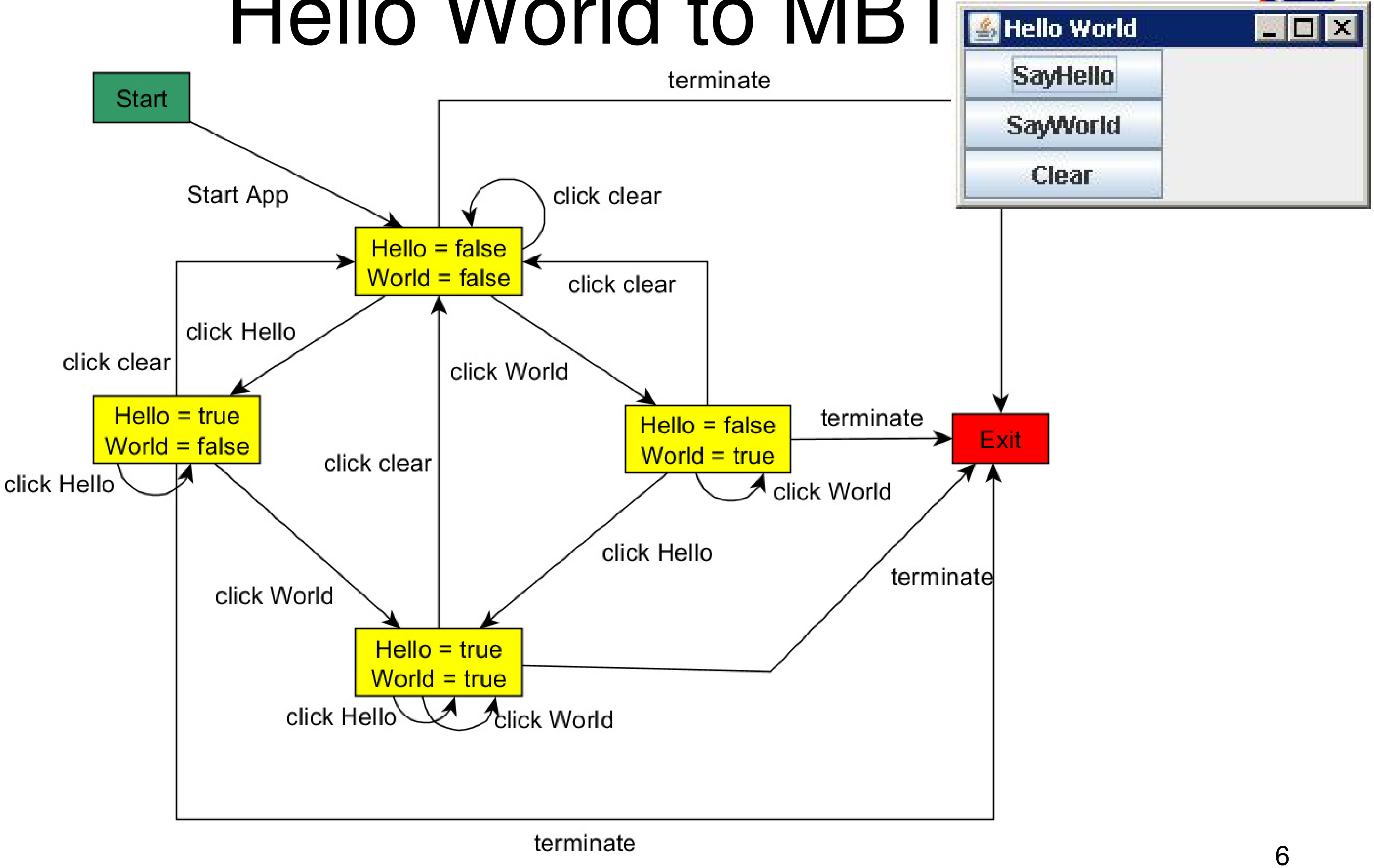
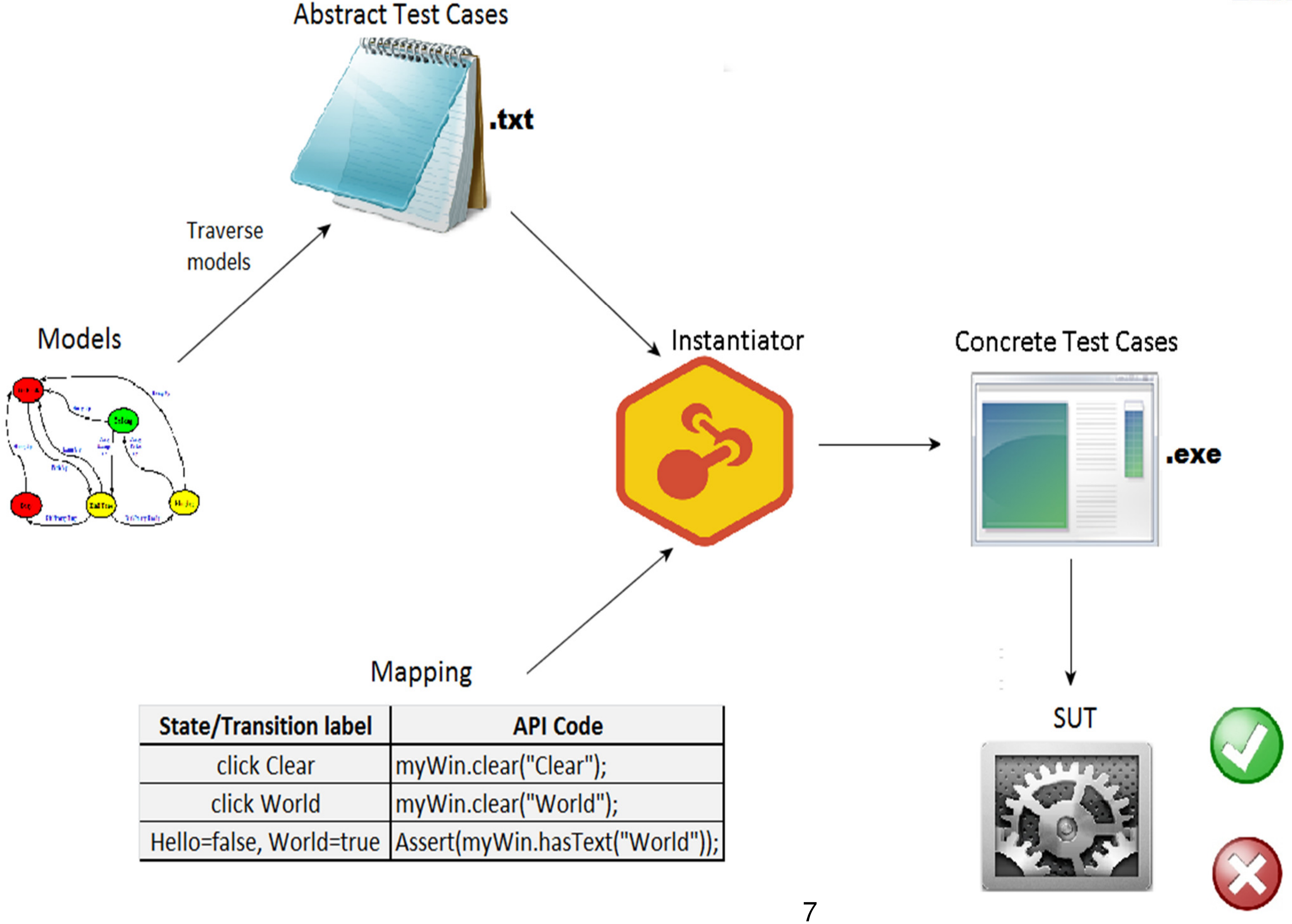
Currently Targeted Projects

- Space Network – White Sands
  - Developed an initial framework for GUI testing
  - Demonstrated the benefits of the framework
  - More work is in progress

Hello World to MBT





Abstract Test Cases

.txt

Traverse models

Models

Instantiator

Concrete Test Cases

.exe

Mapping

State/Transition label	API Code
click Clear	myWin.clear("Clear");
click World	myWin.clear("World");
Hello=false, World=true	Assert(myWin.hasText("World"));

SUT

Advanced MBT

- Explicitly modeling the state space leads to scalability problem
  - Difficult to model all states manually
  - Difficult to slice the model for different scenarios

- We use Spec Explorer for sophisticated MBT
  - Models are C# programs (model programs)
  - State machines are generated from model programs
  - Better scenario control

Advanced MBT …

- Explicit state space modeling is easier to use for small models but is less powerful

- Advanced MBT is very powerful, requires real programming skills

Current Results

- An end-to-end approach for test automation
- Approach found specification and runtime errors
    - Teams fixed those errors!
- Approach works well on different levels:
    - API (Module interface) level testing
    - GUI testing
- Easy to infuse - e.g. GMSEC interns picked up immediately, developed models, found defects.

Sample discovered defects on GMSEC

- Sometimes results in extra message:
  - – sub(x), pub(x), getNextMsg(), getNextMsg()
- Sometimes results in missing message:
  - – sub(x), pub(x), unsub(x), getNextMsg()
- Sometimes results in failure:
  - – connect(), disconnect(), connect()

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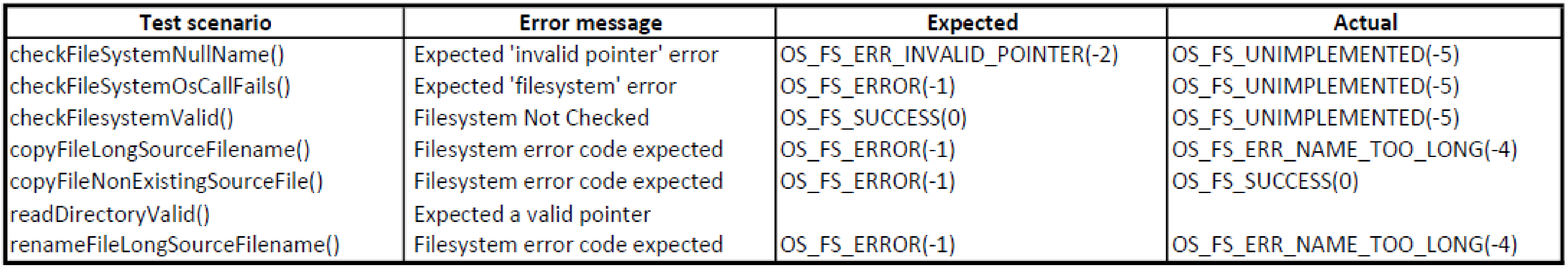
Sample defects using MBT on OSAL

Issues found when running model based tests on the Posix implementation of OSAL:

- File-descriptors issue after removing the file-system:
  - After somewhat long tests we would run out of file-descriptors
  - This would even happen with a newly created file-system
  - Cause: OSAL does not remove file-descriptors when the file-system is removed
  - Effect: inability to to create and open files.

- Wrong error codes returned and unimplemented features:



Test scenario	Error message	Expected	Actual
checkFileSystemNullName()	Expected 'invalid pointer' error	OS_FS_ERR_INVALID_POINTER(-2)	OS_FS_UNIMPLEMENTED(-5)
checkFileSystemOsCallFails()	Expected 'filesystem' error	OS_FS_ERROR(-1)	OS_FS_UNIMPLEMENTED(-5)
checkFilesystemValid()	Filesystem Not Checked	OS_FS_SUCCESS(0)	OS_FS_UNIMPLEMENTED(-5)
copyFileLongSourceFilename()	Filesystem error code expected	OS_FS_ERROR(-1)	OS_FS_ERR_NAME_TOO_LONG(-4)
copyFileNonExistingSourceFile()	Filesystem error code expected	OS_FS_ERROR(-1)	OS_FS_SUCCESS(0)
readDirectoryValid()	Expected a valid pointer		
renameFileLongSourceFilename()	Filesystem error code expected	OS_FS_ERROR(-1)	OS_FS_ERR_NAME_TOO_LONG(-4)

MBT – some limitations

- Modeling requires specification of SUT
  - start with available spec and find spec. issues
- Developers are typically not used to modeling and abstraction
- Difficult to document individual test cases
  - Note: Models summarize all test cases
  - Some customers require document of each test case

ROI

"The GMSEC API provides an abstraction for message oriented middleware and support for multiple programming languages.

Fraunhofer has developed a sophisticated, programming language independent, model of GMSEC API behavior. Tests generated from that model have high-lighted cases where the behavior was not adequately specified, or varied between languages or middleware.

The value of the model was recently demonstrated after the addition of a new C# binding of the GMSEC API. **Fraunhofer generated a large suite of test cases for the new language in one day**. The remarkable turn-around was possible because only the mapping from the language independent test elements to the C# language was needed. "

– Developer, NASA GMSEC Team

Summary and Next Steps

- We're building a practical approach that
  - – Helps in test automation for NASA projects
  - – Has been demonstrated to be
    - effective and efficient,
    - "easy" to infuse
    - applicable to many different types of systems
  - – Contact Dharma (next slide) if you are interested in more info about MBT

Contact

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