

Acceptance Testing

How CSlim and FitNesse Can Help You Test
Your Embedded System



Doug Bradbury
Software Craftsman, 8th Light

Tutorial Environment

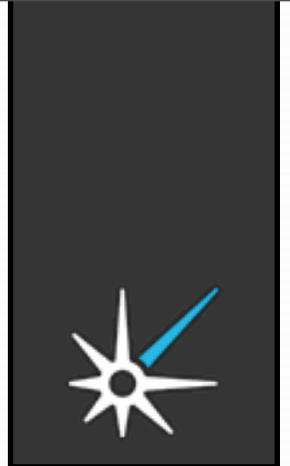


```
git clone git://github.com/dougbradbury/c_learning.git  
cd c_learning  
./bootstrap.sh
```

or with a live CD:

```
cp -R cslim_agile_package c_clearning  
cd c_learning  
git pull  
./bootstrap.sh
```

Overview



Talk w/ exercises: Acceptance Tests

Tutorial: Writing Acceptance tests

Tutorial: Fitnesse

Tutorial: CSlim

Talk: Embedded Systems Integration

Bonus Topics

Introductions



Who are you?

Where do you work?

What experience do you have with ...
embedded systems?

acceptance testing?

FitNesse and Slim?

Objectives



As a result of this course you will be able to:

Understand the purposes of acceptance testing;

Use acceptance tests to define and negotiate scope on embedded systems projects;

Integrate a CSlim Server into your embedded systems;

Objectives (cont)



As a result of this course you will be able to:

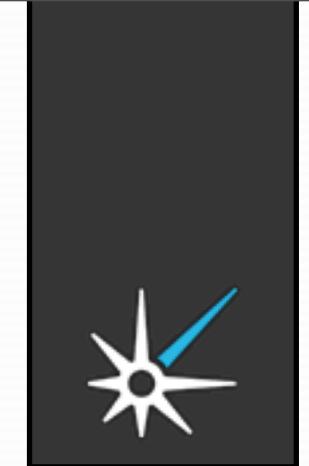
Add CSlim fixtures to your embedded system;

Write Fitnesse tests to drive the execution of CSlim fixtures;

Write and maintain suites of tests in a responsible manner.

Points on a star

How many points does this star have?



Star Point Specification

Points on a star are counted by the number of **exterior** points.

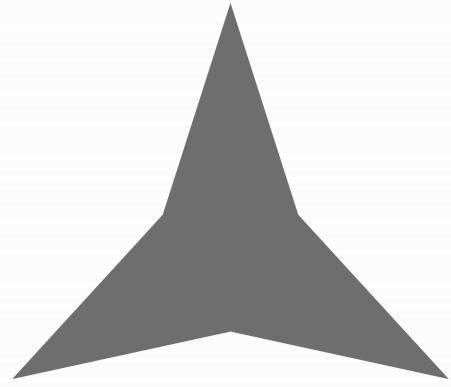


Points on a star

How many points does this star have?



By Example



3



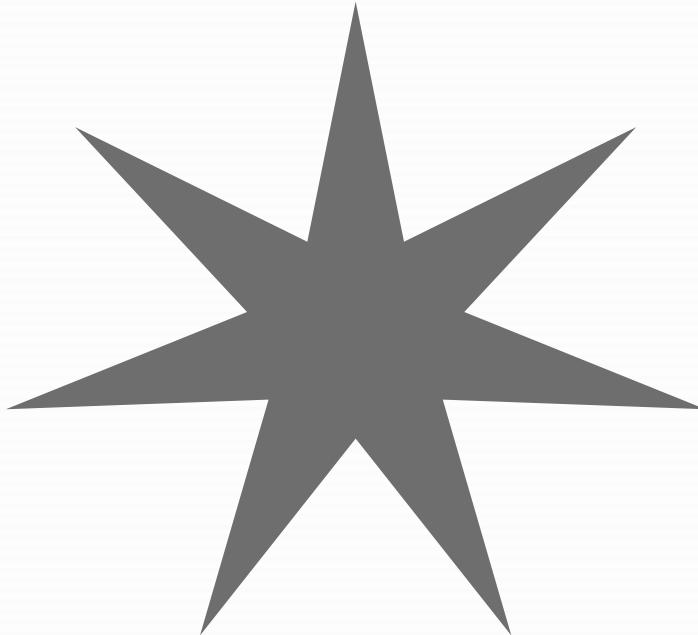
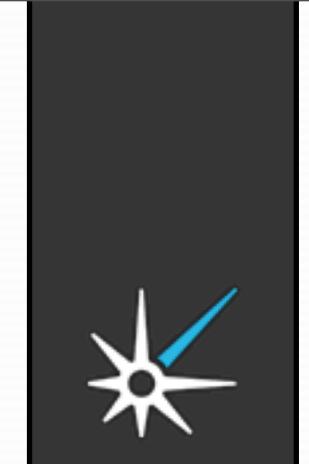
5



9

Points on a star

Now, how many points does this star have?



Robo-draw

Pick a partner ...



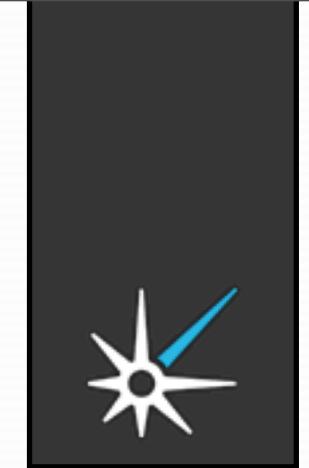
Acceptance Testing

Collaboratively producing examples of what
a piece of software is supposed to do



Unit Tests

help you build the **code right**.



Acceptance Tests

help you build the **right code**.

Acceptance Tests

A collaborative derivation of scope



Acceptance Test

Living Documentation



Acceptance Test

A medium for communication



Acceptance Tests



Acceptance Tests



Fail



Don't test the entire system

[Workspace](#)

[Delete Project](#)

[Configure](#)

[Build History](#) [\(trend\)](#)

- #414 [Mar 23, 2011 10:55:54 AM](#)
- #413 [Mar 18, 2011 4:01:08 PM](#)
- #412 [Mar 18, 2011 3:39:06 PM](#)
- #411 [Mar 18, 2011 1:45:00 PM](#)
- #410 [Mar 18, 2011 9:04:01 AM](#)
- #409 [Mar 18, 2011 8:23:34 AM](#)
- #408 [Mar 17, 2011 1:59:31 PM](#)
- #407 [Mar 16, 2011 12:47:46 PM](#)
- #406 [Mar 15, 2011 6:21:33 PM](#)
- #405 [Mar 15, 2011 4:06:48 PM](#)
- #404 [Mar 14, 2011 5:00:54 PM](#)
- #403 [Mar 14, 2011 2:56:06 PM](#)
- #402 [Mar 14, 2011 2:14:43 PM](#)
- #401 [Mar 8, 2011 5:48:14 PM](#)
- #400 [Mar 2, 2011 2:05:30 PM](#)
- #399 [Mar 1, 2011 4:48:04 PM](#)

This project is currently disabled [Enable](#)



[Workspace](#)



[Recent Changes](#)



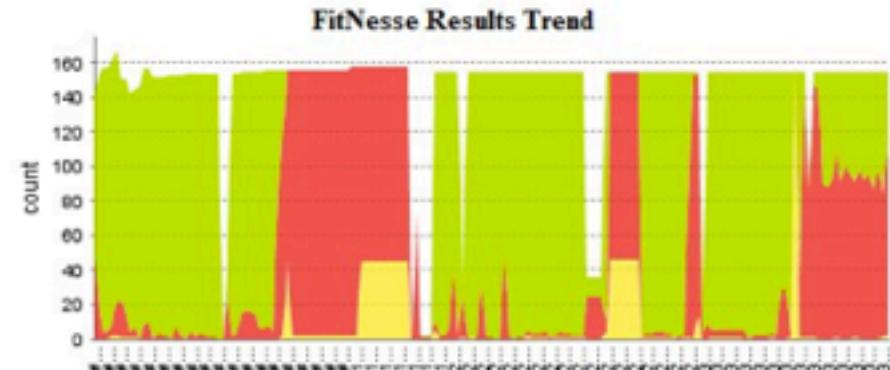
[Latest FitNesse Results \(PassingSuite, 154 pages: 108 wrong, 2 ignored or with exceptions\)](#)

Upstream Projects



Permalinks

- [Last build \(#414\), 26 days ago](#)
- [Last stable build \(#340\), 4 mo 27 days ago](#)
- [Last successful build \(#365\), 3 mo 6 days ago](#)
- [Last failed build \(#414\), 26 days ago](#)
- [Last unstable build \(#365\), 3 mo 6 days ago](#)
- [Last unsuccessful build \(#414\), 26 days ago](#)



Acceptance Tests



Acceptance Tests



Load /
Performance

Acceptance Tests



Acceptance Tests



Acceptance Tests



Acceptance Tests



Collaboratively produced examples

A definition of scope

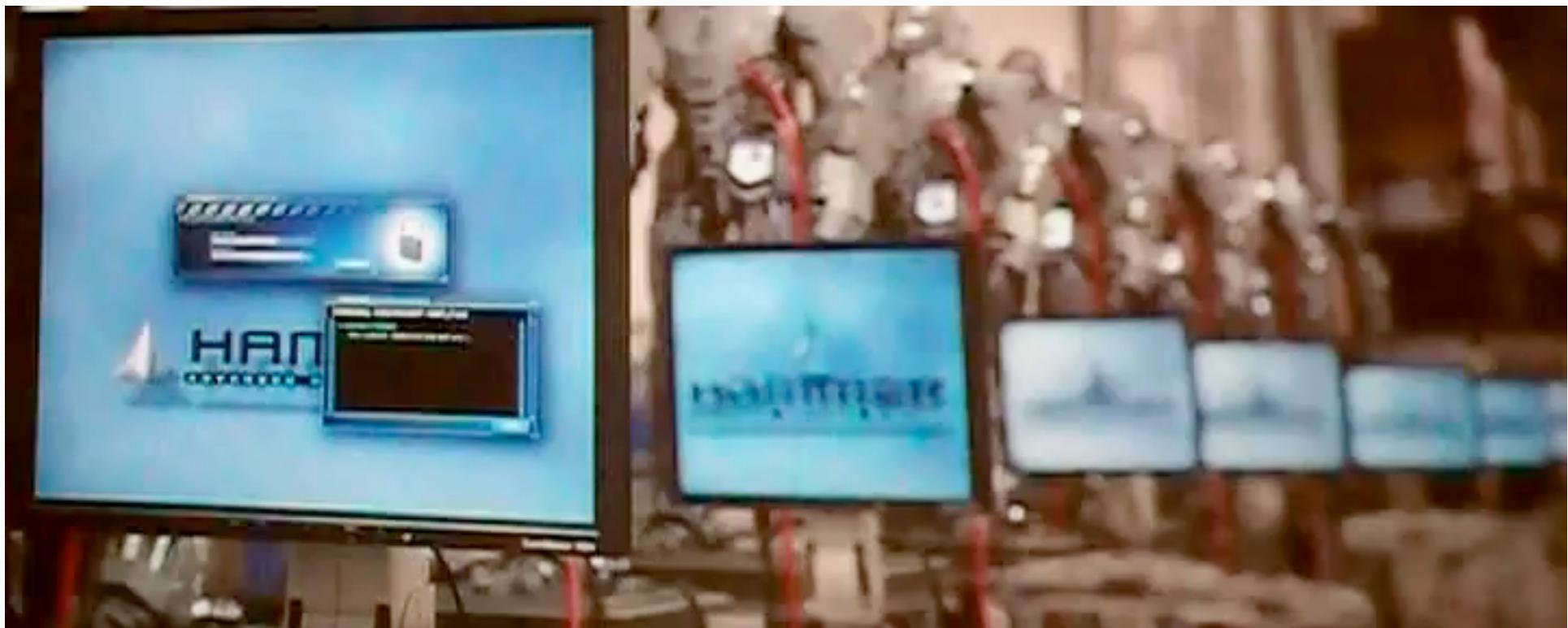
Living documentation

A medium for communication

Why you really need ATs



Твой софт - говно!



Workflow Tests

Given, When, Then
Preconditions, Action, Results



Workflow example



Given a new car traveling at 30 mph

When I fully apply the breaks

Then the car should stop within 35 yards

An example, by example



A treadmill controller



walkncode.com

Treadmill Requirements



It controls the speed of the treadmill.

It increments and decrements the speed.

The max speed is configurable.

It keeps track of total distance walked.

It keeps track of calories burned.

Ambiguities



mph, kph, fps?
inc dec amounts?
range for max speed?
distance in miles, km?
formula for tracking calories?

Treadmill by example



Given treadmill speed is 1.0 mph

When I increment the speed

Then the speed should be 1.1 mph

Your Turn

Write an example for the **decrement speed** scenario.



Write an example for the **max speed** scenario

Decrement Speed



Given treadmill speed is 1.0 mph

When I decrement the speed

Then the speed should be 0.9 mph

Maximum Speed



Given treadmill speed is 3.0 mph

Given max speed is 3.0 mph

When I increment the speed

Then the speed should be 3.0 mph

Calculation Tests

A series of inputs and outputs
Usually captured in table form



Division Test



numerator	denominator	quotient?
10	5	2
39	3	13
5	2	2.5

Calories Burned Test



speed	time	calories?
1.0	60	70
2.0	60	150
3.0	60	220

Your Turn

Write a calculation example for distance traveled.



Distance Travelled



speed	time	distance?
1.0	30	0.5
2.0	30	1.5
1.5	60	3.0

Cumulative Distance



speed	time	distance?
1.0	30	0.5
2.0	30	1.0
1.5	60	1.5

When Do you stop?



Break

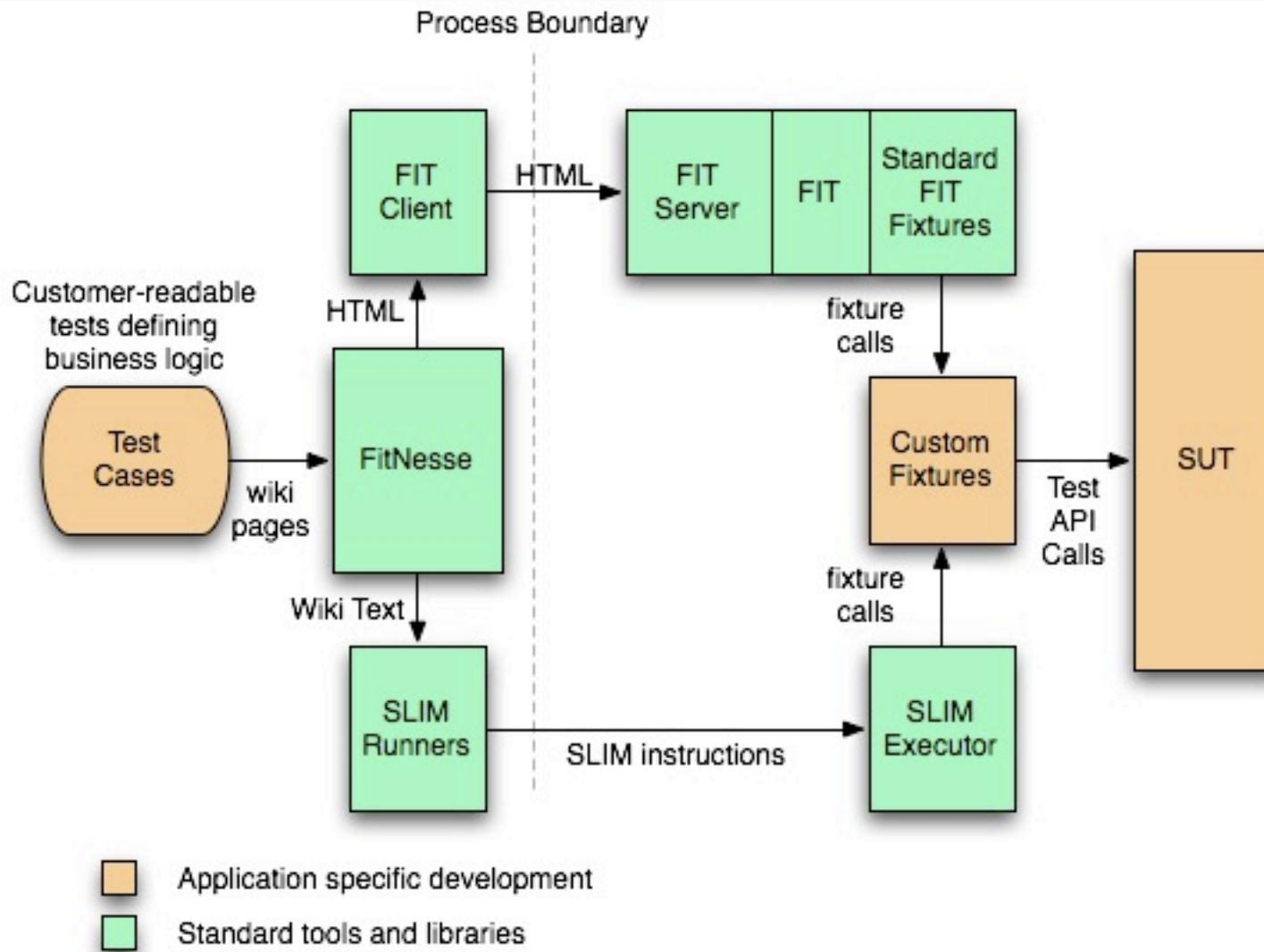


```
git clone git://github.com/dougbradbury/c_learning.git  
cd c_learning  
./bootstrap.sh
```

or with a live CD:

```
cp -R cslim_agile_package c_clearning  
cd c_learning  
git pull  
./bootstrap.sh
```

FitNesse Ecosystem



Starting FitNesse

```
java -jar fitnesse.jar -p 8080 -e o
```



Options

Port: -p 8080

No History: -e o

FitNesse Tutorial



Follow along!

[FitNesse. UserGuide.](#)

OneMinuteDescription [add child]

[A Two-Minute Example](#)

WHAT IS FITNESSE?

FITNESSE IS A SOFTWARE DEVELOPMENT COLLABORATION TOOL

It's a wiki



FrontPage [add child]

WELCOME TO FITNESSE!

THE FULLY INTEGRATED STAND-ALONE AC

The image shows a screenshot of a FrontPage application. On the left, there is a sidebar with three buttons: 'Edit', 'Properties', and 'Where Used'. A red arrow points from the 'Edit' button towards the main content area. The main content area displays the text 'WELCOME TO FITNESSE!' in large, bold, black letters, followed by the subtitle 'THE FULLY INTEGRATED STAND-ALONE AC' in smaller, italicized black letters. At the top of the main content area, there is a link '[add child]'. In the top right corner of the slide, there is a small black square containing a white compass rose icon with one blue ray pointing upwards and to the right.

Editing a page



Try typing a WikiWord (at least 2 capital letters) - Then save

The screenshot shows the FitNesse FrontPage. On the left, there is a green sidebar with the FitNesse logo. The main content area has a light pink background. At the top, the title "FrontPage" is displayed in large blue letters, with a blue "EDIT PAGE:" link below it. A red arrow points from the text "ThisIsAnWikiWord" down towards the edit field. The edit field contains the following text:

```
!1 Welcome to [[FitNesse][FitNesse.FitNesse]]!  
!3 ''The fully integrated stand-alone acceptance testing framework  
  
# Here is a good place to add your first page (WikiWord). For example:  
To add your first "page", click the [[Edit][FrontPage?edit]] button.  
  
| '''To Learn More...''' |  
| [[A One-Minute Description][FitNesse.UserGuide.OneMinuteDescription]] |  
| [[A Two-Minute Example][FitNesse.UserGuide.TwoMinuteExample]] |  
| [[User Guide][FitNesse.UserGuide]] | ''Answer the rest of your questions here...'' |  
| [[Acceptance Tests][FitNesse.SuiteAcceptanceTests]] | ''FitNesse is a great tool for...'' |  
  
!note Release v20110104
```

Creating a new page



Click on the '?' to create that new page

Edit

Properties

Where Used

Search

Files

FrontPage [add child]

ThisIsAnWikiWord[?]

WELCOME TO FitNESSE!

THE FULLY INTEGRATED STAND-ALONE ACCEPTANCE TESTING F...

To add your first "page", click the [Edit](#) button and add a [Wi](#)

Editing a new page



ThisIsAnWikiWord

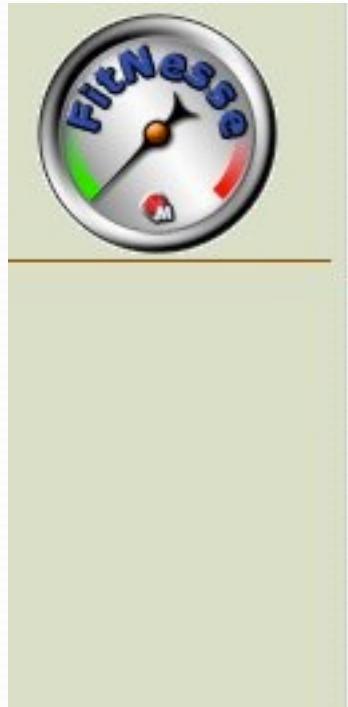
PAGE DOESN'T EXIST. EDIT PAGE:

```
!contents -R2 -g -p -f -h
```

Tables



Tables in FitNesse are defined with pipes '|'



ThisIsAnWikiWord

[EDIT PAGE:](#)

```
|Tables are made with pipes|
|col1|col2|col3|col4|
|b|a|d|c|f|e|g|h|
```

Tables



Save your table

 A circular fitness logo with a stylized figure and the word "Fitness" around the perimeter.

[Edit](#)

[Properties](#)

[Refactor](#)

[Where Used](#)

[Search](#)

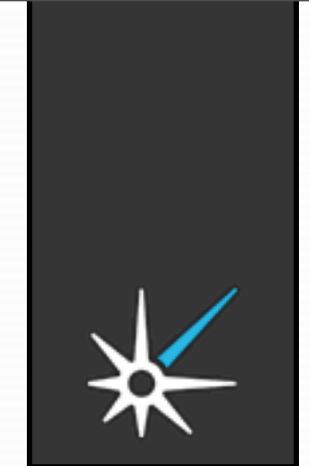
ThisIsAnWikiWord [add child]

Tables are made with pipes			
col1	col2	col3	col4
ba	dc	fe	gh

[From root](#)

User Guide

Learn more about the wiki markup language



User Guide

Let's write some examples



← → C ⌂ localhost:8080/FitNesseTutorial



The screenshot shows the FitNesse web interface. On the left, there's a sidebar with a FitNesse logo icon and two buttons: "Suite" and "Edit". The main content area has a title "FitNesseTutorial [add child]" and a list of defined variables:

- variable defined: TEST_SYSTEM=slim*
- variable defined: TEST_RUNNER=../cslim/CSlim_cslim*
- variable defined: COMMAND_PATTERN=%m*
- variable defined: SLIM_VERSION=0.0*

Another way to add pages



Suite

Edit

Properties

Refactor

FitNesseTutorial [add child]

variable defined: TEST_SYSTEM=slim

variable defined: TEST_RUNNER=..//cslim/CSlim_cslim

variable defined: COMMAND_PATTERN=%m

variable defined: SLIM_VERSION=0.0

Contents:

[Front Page](#) | [User Guide](#)
[root](#) (for global !path's, etc.)

Three types of pages



Normal - Contain only text and links

Test - Executable pages

Suite - a SubWiki of tests (or other suites)

Add Child Page to FitNesseTutorial

<input type="radio"/> Normal <input checked="" type="radio"/> Test <input type="radio"/> Suite <input type="radio"/> Default	<table border="1"><tr><td>Name</td><td>TestDivision</td></tr><tr><td>Content</td><td></td></tr></table>	Name	TestDivision	Content	
Name	TestDivision				
Content					
	<input type="button" value="Cancel"/> <input type="button" value="Add"/>				

Let's view the new test



Suite

Edit

Properties

Refactor

Where Used



FitNesseTutorial [add child]

*variable defined: TEST_SYSTEM=slim
variable defined: TEST_RUNNER=../cslim/CSlim_cslim
variable defined: COMMAND_PATTERN=%m
variable defined: SLIM_VERSION=0.0*

Contents:

- [Test Division +](#)



ro

Test Pages

Behold, the test button



 [FitNesseTutorial.](#)

TestDivision [add child]

[Test](#)

[Edit](#)

[Properties](#)

[Refactor](#)

[... more](#)

[Front Page](#) | [User Guide](#)
root (for global !path's, etc.)

Calculation Test

Edit this test and create a decision table



FitNesseTutorial.

TestDivision

[EDIT PAGE:](#)

```
!|Division!
|numerator|denominator|Quotient?|
|10|5|2|
```

Push the button!



Green means passed

FitNesseTutorial.

TestDivision

TEST RESULTS [\[history\]](#)

Assertions: 1 right, 0 wrong, 0 ignored, 0 exceptions (0.002 seconds)

► *Precompiled Libraries* [Expand All](#) | [Collapse All](#)

Division		
numerator	denominator	Quotient?
10	5	2

[Front Page](#) | [User Guide](#)
[root](#) (for global !path's, etc.)

Test

Edit

Properties

Refactor

Where Used

Search

i

Tests Executed OK

Try some other values



Red means failure

FitNesseTutorial.

TestDivision

TEST RESULTS [\[history\]](#)

Assertions: 1 right, 1 wrong, 0 ignored, 0 exceptions (0.000 seconds)

► *Precompiled Libraries* [Expand All](#) / [Collapse All](#)

Division		
numerator	denominator	Quotient?
10	5	2
11	5	[2.2] expected [9]

[Front Page](#) | [User Guide](#)
[root](#) (for global !path's, etc.)

Test

Edit

Properties

Refactor

Where Used

Search

Line up your columns



Try the “format” button

FitNesseTutorial.
TestDivision
EDIT PAGE:

!Division	!	!	!
inumerator	denominator	Quotient?	!
110	15	12	!
111	15	19	!

Save Spreadsheet to FitNesse FitNesse to Spreadsheet Format wrap



Workflow Test



Create a new test with a script table

[FitNesseTutorial.](#)

TestCounter [add child]

script	Count	
count		
count		
check	counter	2

[Front Page](#) | [User Guide](#)
[root](#) (for global !path's, etc.)

Test

Edit

Properties

Refactor

Where Used

Workflow Test Run



FitNesseTutorial.

TestCounter

TEST RESULTS [\[history\]](#)

Assertions: 1 right, 0 wrong, 0 ignored, 0 exceptions (0.003 seconds)

► *Precompiled Libraries* [Expand All](#) | [Collapse All](#)

script	Count
count	
count	
check	counter
	2

[Front Page](#) | [User Guide](#)
[root](#) (for global !path's, etc.)

Navigation:

- Test
- Edit
- Properties
- Refactor
- Where Used
- Search
- Files

Information:

- i Tests Executed OK**

Workflow failure



FitNesseTutorial.

TestCounter

TEST RESULTS [\[history\]](#)

Assertions: 0 right, 1 wrong, 0 ignored, 0 exceptions (0.005 seconds)

► *Precompiled Libraries* [Expand All](#) | [Collapse All](#)

script	Count
count	
count	
count	
check	counter [3] expected [2]

[Front Page](#) | [User Guide](#)
root (for global !path's, etc.)

Test

Edit

Properties

Refactor

Where Used

Search

Files

Versions

Exercise



Create a TreadmillSuite

Create the following tests

TestIncrementTreadmill (workflow)

TestDecrementTreadmill (workflow)

TestMaxSpeed (workflow)

TestCumulativeDistance (calculation)

TestTotalDistance (calculation)



[TreadmillControlSuite](#).

TestIncrementSpeed [add child]

script	Treadmill	
given treadmill speed	1.0	
increment speed		
check	target speed	1.1



[TreadmillControlSuite.](#)

TestDecrementSpeed [add child]

script	Treadmill	
given treadmill speed	1.0	
decrement speed		
check	target speed	0.9



[TreadmillControlSuite.](#)

TestMaxSpeed [add child]

script	Treadmill	
given max speed	3.0	
given treadmill speed	3.0	
increment speed		
check	target speed	3.0

[Front Page](#) | [User Guide](#)
[root](#) (for global !path's, etc.)



[TreadmillControlSuite.](#)

TestCumulativeDistance

[add child]

Treadmill Cumulative Distance		
speed	time	distance?
1.0	30	0.5
2.0	30	1.5
1.5	60	3.0

[Front Page](#) | [User Guide](#)
[root](#) (for global !path's, etc.)



[TreadmillControlSuite.](#)

TestTotalDistance

[add child]

Treadmill Distance		
speed	time	distance?
1.0	30	0.5
2.0	30	1.0
1.5	60	1.5

[Front Page](#) | [User Guide](#)
[root](#) (for global !path's, etc.)

It's Fixture Time



cslim/fixtures/Fixtures.c

```
1 #include "Fixtures.h"
2
3 SLIM_FIXTURES
4     SLIM.fixture(Division)
5     SLIM.fixture(Count)
6     SLIM.fixture(EmployeePayRecordsRow)
7     SLIM.fixture(ExceptionsExample)
8     SLIM.fixture(Multiplication)
9 SLIM_END
10
11
```

It's Fixture Time



cslim/fixtures/DecisionTableExample.c

```
63  
64 SLIM_CREATE_FIXTURE(Division)  
65   SLIM_FUNCTION(setNumerator)  
66   SLIM_FUNCTION(setDenominator)  
67   SLIM_FUNCTION(Quotient)  
68   SLIM_FUNCTION(execute)  
69   SLIM_FUNCTION(reset)  
70   SLIM_FUNCTION(table)  
71 SLIM_END  
72
```

Fixture “Objects”



cslim/fixtures/DecisionTableExample.c

```
6
7 typedef struct Division
8 {
9     float numerator;
10    float denominator;
11    char result[32];
12 } Division;
13
14 void* Division_Create(StatementExecutor* errorHandler, SlimList* args)
15 {
16     Division* self = (Division*)malloc(sizeof(Division));
17     memset(self, 0, sizeof(Division));
18     return self;
19 }
20
21 void Division_Destroy(void* void_self)
22 {
23     free(void_self);
24 }
```

Fixture functions

cslim/fixtures/DecisionTableExample.c



```
25  
26 static char* setNumerator(void* void_self, SlimList* args) {  
27     Division* self = (Division*)void_self;  
28     self->numerator = atof(SlimList_GetStringAt(args, 0));  
29     return "";  
30 }  
31 }
```

SlimList

cslim/include/CSlim/SlimList.h



```
16 SlimList * SlimList_GetListAt(SlimList* self, int index);
17 char * SlimList_GetStringAt(SlimList* self, int index);
18 double SlimList_GetDoubleAt(SlimList* self, int index);
19 SlimList* SlimList_GetHashAt(SlimList* self, int index);
```

Returning a Value



cslim/fixtures/DecisionTableExample.c

```
39
40 static char* Quotient(void* void_self, SlimList* args) {
41     Division* self = (Division*)void_self;
42     float quotient = self->numerator / self->denominator;
43     snprintf(self->result, 32, "%g", quotient);
44     return self->result;
45 }
46
```

All return values are strings.

Extra functions



Decision tables have a few optional functions.

```
static char* execute(void* void_self, SlimList *args) {  
    return "";  
}
```

```
static char* reset(void* void_self, SlimList *args) {  
    return "";  
}
```

Order of Execution



all setters
execute()
all getters
reset()

Division		
numerator	denominator	Quotient?
10	5	2
11	5	9

Let's build a fixture



CheatSuite.TreadmillControlSuite

[CheatSuite.](#)

TreadmillControlSuite [add child]

*variable defined: TEST_SYSTEM=slim
variable defined: TEST_RUNNER=../treadmill/Treadmill_acceptance_tests
variable defined: COMMAND_PATTERN=%m
variable defined: SLIM_VERSION=0.0*

Contents:

- [Test Calories Burned +](#)
- [Test Cumulative Distance +](#)
- [Test Decrement Speed +](#)
- [Test Increment Speed +](#)
- [Test Max Speed +](#)
- [Test Total Distance +](#)

[Front Page](#) | [User Guide](#)
[root](#) (for global !path's, etc.)

TestIncrementSpeed



Exceptions are yellow

CheatSuite. TreadmillControlSuite.

TestIncrementSpeed

TEST RESULTS [\[history\]](#)

Assertions: 0 right, 0 wrong, 0 ignored, 8 exceptions (0.001 seconds)

► Precompiled Libraries [Expand All](#) / [Collapse All](#)

script	Treadmill Could not find class Treadmill.	
given treadmill speed The instance scriptTableActor. does not exist	1.0	
increment speed The instance scriptTableActor. does not exist		
check	target speed	1.1 The instance scriptTableActor. does not exist

[Front Page](#) | [User Guide](#)
[root](#) (for global !path's, etc.)

Test

Edit

Properties

Refactor

Where Used

Search

Files

Versions

i Tests Executed OK

TestIncrementSpeed



Let's create a fixture called "Treadmill"

CheatSuite. TreadmillControlSuite.

TestIncrementSpeed

TEST RESULTS [\[history\]](#)

Assertions: 0 right, 0 wrong, 0 ignored, 8 exceptions (0.001 seconds)

▶ Precompiled Libraries [Expand All](#) / [Collapse All](#)

script	Treadmill Could not find class Treadmill.	
given treadmill speed The instance scriptTableActor. does not exist	1.0	
increment speed The instance scriptTableActor. does not exist		
check	target speed	1.1 The instance scriptTableActor. does not exist

[Front Page](#) | [User Guide](#)
[root](#) (for global !path's, etc.)

Test Edit Properties Refactor Where Used Search Files Versions

Create a Fixture



```
cd treadmill/fixtures/  
cp FixtureTemplate.c Treadmill.c  
sed -i '' s/ExampleFixture/Treadmill/g Treadmill.c
```

```
#include <stdlib.h>  
#include <memory.h>  
#include <stdio.h>  
#include "Fixtures.h"  
#include "SlimList.h"  
  
typedef struct Treadmill  
{  
    char result[32];  
} Treadmill;  
  
void* Treadmill_Create(StatementExecutor* errorHandler, SlimList* args)  
{  
    Treadmill* self = (Treadmill*)malloc(sizeof(Treadmill));  
    memset(self, 0, sizeof(Treadmill));  
    return self;  
}  
  
void Treadmill_Destroy(void* void_self)  
{  
    Treadmill* self = (Treadmill*)void_self;  
    free(self);  
}  
  
static char* exampleMethod(void* void_self, SlimList* args)  
{  
    Treadmill* self = (Treadmill*)void_self;  
    return "";  
}  
  
SLIM_CREATE_FIXTURE(Treadmill)  
SLIM_FUNCTION(exampleMethod)  
SLIM_END
```

Register the Fixture

fixtures/FixtureMain.c



```
#include "Fixtures.h"

SLIM_FIXTURES
    SLIM_FIXTURE(Treadmill)
SLIM_END
```

ReBuild the ‘at’ target

```
%> make at
```



Run the Test again



Fixture was found!

CheatSuite. TreadmillControlSuite.

TestIncrementSpeed

TEST RESULTS [\[history\]](#)



Tests
Executed OK

Assertions: 0 right, 0 wrong, 0 ignored, 6 exceptions (0.005 seconds)

► Precompiled Libraries

[Expand All](#) | [Collapse All](#)

script	Treadmill	
given treadmill speed Method givenTreadmillSpeed[1] not found in Treadmill.	1.0	
increment speed Method incrementSpeed[0] not found in Treadmill.		
check	target speed	1.1 Method targetSpeed[0] not found in Treadmill.

The First Method



givenTreadmillSpeed

CheatSuite. TreadmillControlSuite.

TestIncrementSpeed

TEST RESULTS [\[history\]](#)



Tests

Executed OK

Assertions: 0 right, 0 wrong, 0 ignored, 6 exceptions (0.005 seconds)

► Precompiled Libraries

[Expand All](#) | [Collapse All](#)

script	Treadmill	
given treadmill speed Method givenTreadmillSpeed[1] not found in Treadmill.	1.0	
increment speed Method incrementSpeed[0] not found in Treadmill.		
check	target speed	1.1 Method targetSpeed[0] not found in Treadmill.

The First Method

treadmill/fixtures/Treadmill.c



```
static char* givenTreadmillSpeed(void* void_self, SlimList* args)
{
    Treadmill* self = (Treadmill*)void_self;
    return "";
}

SLIM_CREATE_FIXTURE(Treadmill)
    SLIM_FUNCTION(givenTreadmillSpeed)
SLIM_END
```

IncrementSpeed

Implement Increment Speed on your own.



targetSpeed

Return a value to make the test fail.



```
static char* targetSpeed(void* void_self, SlimList* args)
{
    Treadmill* self = (Treadmill*)void_self;
    return "0.0";
}
```

targetSpeed Failure



CheatSuite. TreadmillControlSuite.

TestIncrementSpeed

TEST RESULTS [\[history\]](#)



Tests
Executed OK

Assertions: 0 right, 1 wrong, 0 ignored, 0 exceptions (0.003 seconds)

► Precompiled Libraries

[Expand All](#) | [Collapse All](#)

script	Treadmill
given treadmill speed	1.0
increment speed	
check	target speed [0.0] expected [1.1]

[Front Page](#) | [User Guide](#)
[root](#) (for global !path's, etc.)

Treadmill Api



include/treadmill/Api.h

```
10 typedef struct ApiStruct * Api;
11
12 Api Api_Create(void);
13 void Api_Destroy(Api);
14 double Api_GetTargetSpeed(Api);
15 void Api_SetTargetSpeed(Api, double);
16 void Api_IncrementTargetSpeed(Api);
17 void Api_DecrementTargetSpeed(Api);
18 void Api_SetMaximumSpeed(Api, double);
19 double Api_DistanceTravelled(Api);
20 void Api_Reset(Api);
```

Declare an instance



treadmill/fixtures/Treadmill.c

```
8 typedef struct Treadmill
9 {
10     char result[32];
11     Api api;
12 } Treadmill;
```

Create & Destroy



treadmill/fixtures/Treadmill.c

```
14 void* Treadmill_Create(StatementExecutor* errorHandler, SlimList* args)
15 {
16     Treadmill* self = (Treadmill*)malloc(sizeof(Treadmill));
17     memset(self, 0, sizeof(Treadmill));
18     self->api = Api_Create();
19     return self;
20 }
21
22 void Treadmill_Destroy(void* void_self)
23 {
24     Treadmill* self = (Treadmill*)void_self;
25     Api_Destroy(self->api);
26     free(self);
27 }
```

Reading from a SlimList



treadmill/fixtures/Treadmill.c

```
29 static char* givenTreadmillSpeed(void* void_self, SlimList* args)
30 {
31     Treadmill* self = (Treadmill*)void_self;
32     double speed = SlimList_GetDoubleAt(args, 0);
33     Api_SetTargetSpeed(self->api, speed);
34     return "";
35 }
36 }
```

No Parameters



treadmill/fixtures/Treadmill.c

```
36
37 static char* incrementSpeed(void* void_self, SlimList* args)
38 {
39     Treadmill* self = (Treadmill*)void_self;
40     Api_IncrementTargetSpeed(self->api);
41     return "";
42 }
43
```

Result

treadmill/fixtures/Treadmill.c



```
44 static char* targetSpeed(void* void_self, SlimList* args)
45 {
46     Treadmill* self = (Treadmill*)void_self;
47     snprintf(self->result, 32, "% .1f", Api_GetTargetSpeed(self->api));
48     return self->result;
49 }
50 }
```

ReBuild the ‘at’ target

%> make at



Woot!



Green is good

[CheatSuite](#). [TreadmillControlSuite](#).



TestIncrementSpeed

TEST RESULTS [\[history\]](#)

Tests

Executed OK

Assertions: 1 right, 0 wrong, 0 ignored, 0 exceptions (0.001 seconds)

[Expand All](#) | [Collapse All](#)

script	Treadmill
given treadmill speed	1.0
increment speed	
check	target speed 1.1

[Front Page](#) | [User Guide](#)
[root](#) (for global !path's, etc.)

Exercise

Add fixture methods to Treadmill.c to support:



TestDecrementSpeed
TestMaxSpeed

Catch up

If you need to catch up with the group



`cp cheat_fixtures/Treadmill.c fixtures`

Calculation Test



[CheatSuite](#). [TreadmillControlSuite](#).

TestCumulativeDistance



TEST RESULTS [\[history\]](#)

Tests
Executed OK

Assertions: 0 right, 0 wrong, 0 ignored, 29 exceptions (0.002 seconds)

► *Precompiled Libraries*

[Expand All](#) | [Collapse All](#)

Treadmill Cumulative Distance Could not find class TreadmillCumulativeDistance.

speed	time	distance?
1.0 The instance decisionTable_0. does not exist	30 The instance decisionTable_0. does not exist	0.5 The instance decisionTable_0. does not exist
2.0 The instance decisionTable_0. does not exist	30 The instance decisionTable_0. does not exist	1.5 The instance decisionTable_0. does not exist
1.5 The instance decisionTable_0. does not exist	60 The instance decisionTable_0. does not exist	3.0 The instance decisionTable_0. does not exist

Create a new fixture



```
cd treadmill/fixtures/  
cp FixtureTemplate.c TreadmillCumulativeDistance.c  
sed -i '' s/ExampleFixture/  
TreadmillCumulativeDistance/g  
TreadmillCumulativeDistance.c
```

```
35 #include "Fixtures.h"  
36  
37 SLIM_FIXTURES  
38   SLIM.fixture(TreadmillCumulativeDistance)  
39   SLIM.fixture(Treadmill)  
40 SLIM_END  
41
```

Decision table naming



speed => setSpeed

time => setTime

distance? => distance

[CheatSuite](#). [TreadmillControlSuite](#).

TestCumulativeDistance



Tests
Executed OK

Assertions: 0 right, 0 wrong, 0 ignored, 18 exceptions (0.002 seconds)

► Precompiled Libraries

[Expand All](#) | [Collapse All](#)

Treadmill Cumulative Distance

speed	time	distance?
1.0 Method setSpeed[1] not found in TreadmillCumulativeDistance.	30 Method setTime[1] not found in TreadmillCumulativeDistance.	0.5 Method distance[0] not found in TreadmillCumulativeDistance.
2.0 Method setSpeed[1] not found in TreadmillCumulativeDistance.	30 Method setTime[1] not found in TreadmillCumulativeDistance.	1.5 Method distance[0] not found in TreadmillCumulativeDistance.
1.5 Method setSpeed[1] not found in TreadmillCumulativeDistance.	60 Method setTime[1] not found in TreadmillCumulativeDistance.	3.0 Method distance[0] not found in TreadmillCumulativeDistance.

Make it red.

Implement stubs for:

setTime

setSpeed

distance



Does anybody really know what time it is?



We will use a link-time seam to mock out uptime.

include/hardware/Uptime.h

```
11 void Uptime_Create(void);  
12 void Uptime_Destroy(void);  
13 long Uptime_MilliSeconds(void);
```

FakeUptime



mocks/hardware/FakeUptime.h

```
10  
11 #include "Uptime.h"  
12 extern long uptimeMillis;
```

mocks/hardware/FakeUptime.c

```
1 #include "Uptime.h"  
2 int uptimeMillis;  
3  
4 void Uptime_Create(void)  
5 {  
6     uptimeMillis = 0;  
7 }  
8  
9 long Uptime_MilliSeconds(void)  
10 {  
11     return uptimeMillis;  
12 }  
13
```

Back to our fixture



Use the uptimeMillis extern to set the current time

fixtures/TreadmillCumulativeDistance.c

```
7 #include "hardware/FakeUptime.h"
```

```
31
32 static char* execute(void* void_self, SlimList *args) {
33     TreadmillCumulativeDistance* self = (TreadmillCumulativeDistance*)void_se
34     Api_SetTargetSpeed(self->api, self->speed);
35     uptimeMillis += self->time;
36     return "";
37 }
38 }
```

Exercise



Finish the TreadmillCumulativeDistance fixture.

Extra credit: TreadmillDistance fixture.
(hint: you'll need to use the reset function)

Cumulative Distance



fixtures/TreadmillCumulativeDistance.c

```
9  typedef struct TreadmillCumulativeDistance
10 {
11     char result[32];
12     Api api;
13     double speed;
14     double time;
15 } TreadmillCumulativeDistance;
16
```

Cumulative Distance



fixtures/TreadmillCumulativeDistance.c

```
39 static char* setSpeed(void* void_self, SlimList *args) {
40     TreadmillCumulativeDistance* self = (TreadmillCumulativeDistance*)void_se
41     self->speed = SlimList_GetDoubleAt(args, 0);
42     return "";
43 }
44
45 static char* setTime(void* void_self, SlimList *args) {
46     TreadmillCumulativeDistance* self = (TreadmillCumulativeDistance*)void_se
47     double minutes = SlimList_GetDoubleAt(args, 0);
48     self->time = minutes*60*1000;
49     return "";
50 }
```

Cumulative Distance



fixtures/TreadmillCumulativeDistance.c

```
31
32 static char* execute(void* void_self, SlimList *args) {
33     TreadmillCumulativeDistance* self = (TreadmillCumulativeDistance*)void_se
34     Api_SetTargetSpeed(self->api, self->speed);
35     uptimeMillis += self->time;
36     return "";
37 }
38 }
```

Cumulative Distance



fixtures/TreadmillCumulativeDistance.c

```
52 static char* distance(void* void_self, SlimList *args) {
53     TreadmillCumulativeDistance* self = (TreadmillCumulativeDistance*)void_se
54     double d = Api_DistanceTravelled(self->api);
55     snprintf(self->result, 32, "%0.1f", d);
56     return self->result;
57 }
```

Total Distance

fixtures/TreadmillDistance.c



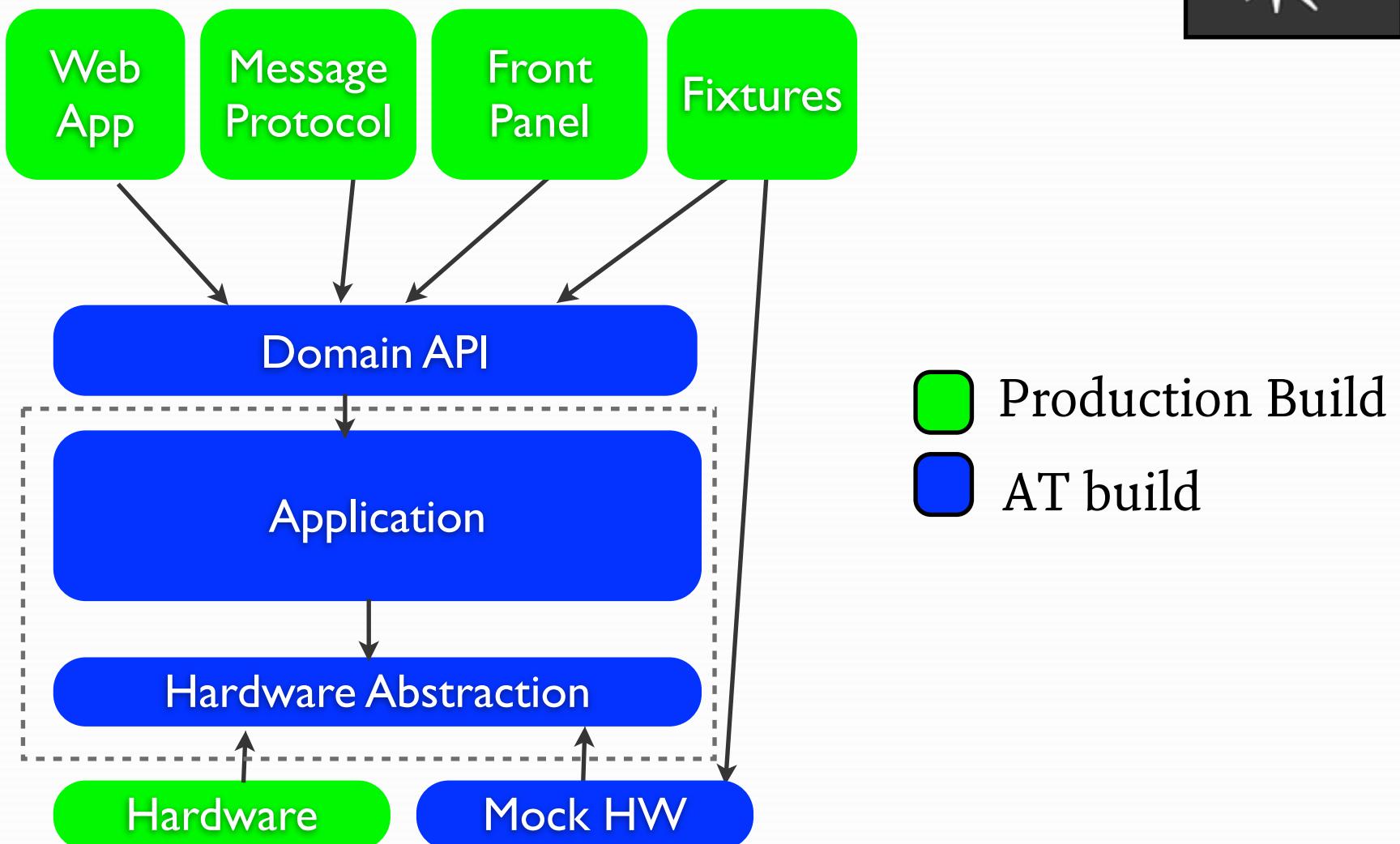
```
30 static char* reset(void* void_self, SlimList *args) {
31     TreadmillDistance* self = (TreadmillDistance*)void_self;
32     Api_Reset(self->api);
33     return "";
34 }
35 }
```

Break

Take 5.



System Architecture



Hardware Abstraction



Remember, acceptance tests are not about testing the hardware.

Hardware Abstraction



include/hardware/Pwm.h

```
4 void Pwm_Create(void);
5 void Pwm_Destroy(void);
6
7 void Pwm_Start();
8 void Pwm_Stop();
9 void Pwm_SetDutyCycle(double percent);
10 void Pwm_SetPeriod(int microseconds);
```

Hardware Abstraction



mocks/hardware/FakePwm.h

```
4 #include "Pwm.h"  
5  
6 extern int FakePwm_isRunning;  
7 extern int FakePwm_period;  
8 extern double FakePwm_dutyCycle;
```

Hardware Abstraction



mocks/hardware/FakePwm.c

```
3 int FakePwm_isRunning = 0;
4 double FakePwm_dutyCycle = 0.0;
5 int FakePwm_period = 0;
6
11 void Pwm_Start(void) { FakePwm_isRunning = 1; }
13 void Pwm_Stop(void) { FakePwm_isRunning = 0; }
15 void Pwm_SetDutyCycle(double percent)
    { FakePwm_dutyCycle = percent; }
17 void Pwm_SetPeriod(int us) { FakePwm_period = us; }
```

UI abstraction



The UI uses the same API as the tests



UI Abstraction



Detect button press ...

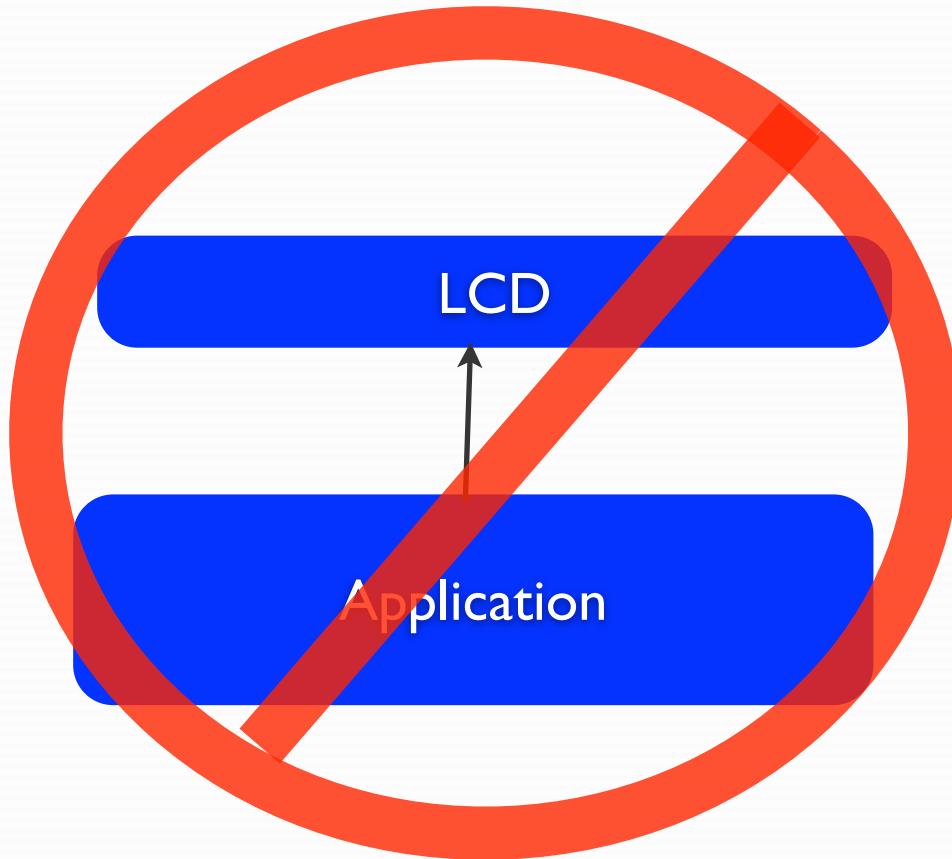
Api_IncrementTargetSpeed();

....

UI Abstraction



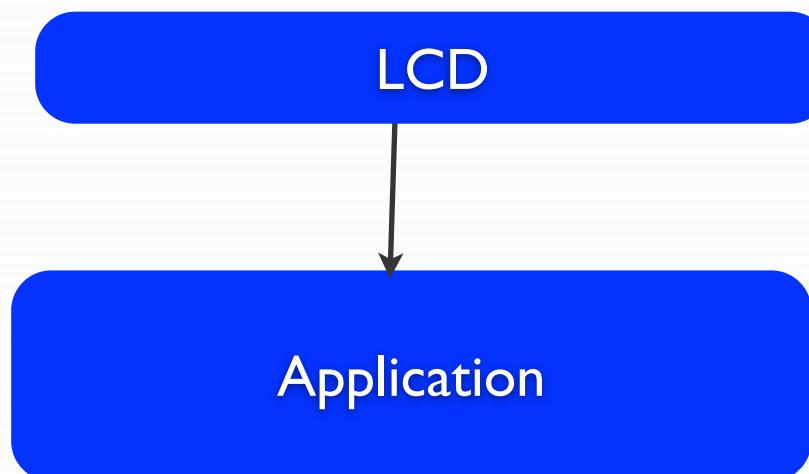
What about Displays?



UI Abstraction



Turn the dependency around with an observer



UI Abstraction



Observer Pattern

```
void onSpeedChange(double speed) {  
    /*update speed display */  
}
```

```
Api_registerSpeedObserver(&onSpeedChange);
```

Messaging

Uses the same API as everyone else.



Test message parsing independently.

Timers

Can't wait on real time



Timer also hit the same API

Interrupts

Generate events in system that can be simulated



Then what's the point?



Acceptance tests are not entire system tests.

They are a software collaboration medium.

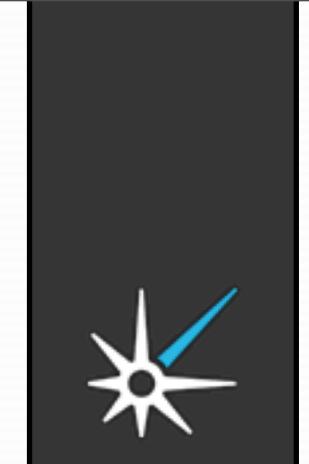
Running on target



Treadmill Cumulative Distance				
speed	time	distance?		time?
1.0	30	[0.0] expected [0.5]		30528

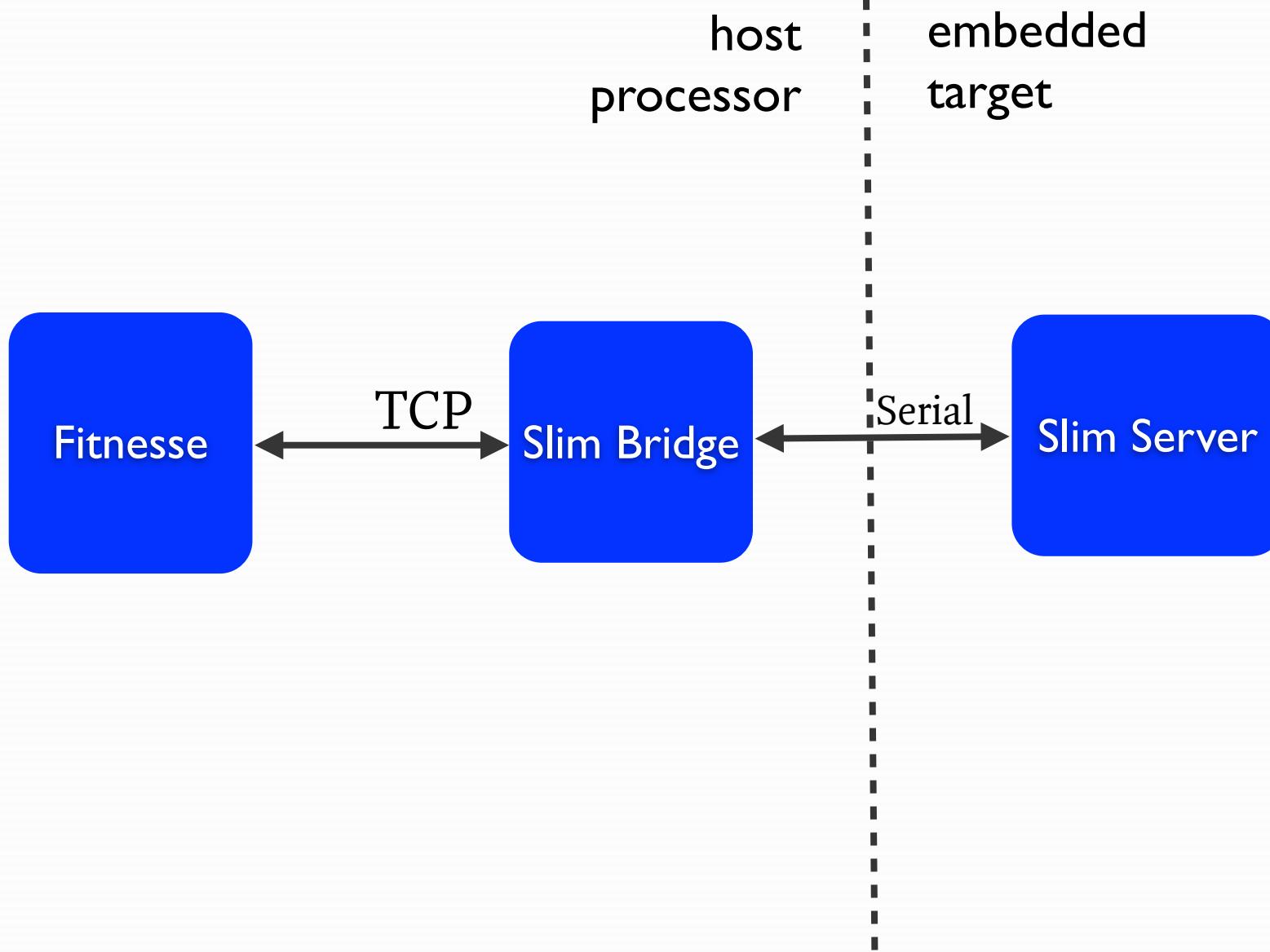
Serial Bridge

What about running on a target without an ethernet stack?



https://github.com/dougbradbury/slim_bridge

Running on target



On Target Demo



Porting CSlim



```
▼ src
  ▼ Com
    □ SocketServer.c
    □ TcpComLink.c
  ▶ ComArduino
  ▶ ComWin32
  ▼ CSlim
    □ ListExecutor.c
    □ Slim.c
    □ SlimConnectionHandler.c
    □ SlimList.c
    □ SlimListDeserializer.c
    □ SlimListSerializer.c
    □ SlimUtil.c
    □ StatementExecutor.c
    □ SymbolTable.c
  --
```

Porting CSlim



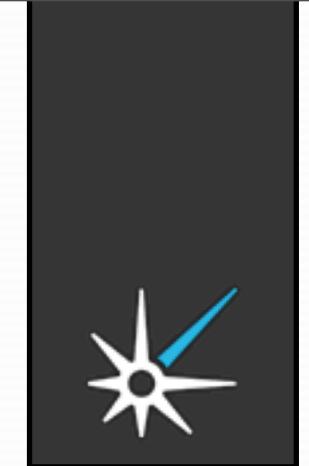
Implement a TCP socket Server
only needs to handle one connection at a
time

calls Slim_HandleConnection with
pointers to send / recv functions

```
5
6 typedef int(*com_func_t)(void * handle, char * msg, int length);
7 typedef char * (*handler_func_t)(void *, char *);
8
9
10 int Slim_HandleConnection(Slim* self, void* comLink, com_func_t send, com_func_t recv);
```

You can help

Still some features missing (sut, libraries)



Contribute your port back to the project

Help reduce memory usage

Slim(mer)?

Bonus topics

Multi-parameter script table functions

Returning Lists

Query tables



Multiple Parameters



Function name alternates with parameters

script	Treadmill		
given treadmill speed	1.0	and incline	5.0
increment speed			
check	target speed 1.1		

Multiple Parameters



Function name alternates with parameters

script	Treadmill	
given treadmill speed	1.0	and incline 5.0
increment speed		
check	target speed	1.1

Multiple Parameters



Function name alternates with parameters

ot	Treadmill
n treadmill speed Method givenTreadmillSpeedAndIncline[2] ot found in Treadmill.	1.0 and
ement speed	
tk	target speed [0.1]

Returning Lists



cslim/fixtures/QueryTableExample

```
31  SlimList* id = SlimList_Create();  
32  SlimList_AddString(id, "id");  
33  SlimList_AddString(id, "1");  
34
```

...

```
47  self->result = SlimList_Serialize(records);  
48
```

Query Tables



Rows of Records

Order doesn't matter

Query: EmployeePayRecordsRow	
id	pay
1	1000
[2] missing	1050

Query Tables



Return a List of records

A record is a list or key, value pairs

A key, value pair is a two element list

```
(  
  ((id, 1), (pay, 1000))  
  ((id 2), (pay, 1500))  
)
```

Query Tables



The list must be serialized and returned from the query function.

cslim/fixtures/QueryTableExample.c

```
47     self->result = SlimList_Serialize(records);  
48 }
```

Recommended Reading



Specification by Example - Gojko Adzic

Test Driven Development for Embedded C -
James Grenning

Fit - For Developing Software - Mugridge /
Cunningham

FitNesse Users Guide