# mbeddr C

An extensible version of the C programming language for Embedded Programming

C the Difference - C the Future

Bundesministerium für Bildung und Forschung

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LEAR CORPORATION SICK Sensor Intelligence. fortiss innovation in software and systems itemis

# What if…

you could change languages like you can change programs?

# A Test, written in essentially normal C

```
module WriteATestCase from cdesignpaper.unittest imports nothing {

  var int8_t failedTests;

  int32_t main(int32_t argc, int8_t*[ ] argv) {
    testMultiply();
    return failedTests;
  } main (function)

  void testMultiply() {
    if ( times2(21) != 42 ) { failedTests++; } if
  } testMultiply (function)

  int8_t times2(int8_t a) {
    return 2 * a;
  } times2 (function)
}
```

- The same test, but now using additional language concepts from the unit test extension

```
module UnitTestDemo from cdesignpaper.unittest imports nothing {

  int32_t main(int32_t argc, int8_t*[ ] argv) {
    return test testMultiply;
  } main (function)

  exported test case testMultiply {
    assert(0) times2(21) == 42;
  } testMultiply(test case)

  int8_t times2(int8_t a) {
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  int8_t times2(int8_t a) {
    return 2 * a;
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}
```

Test Cases are a kind of void function, but with adapted syntax

- The same test, but now using additional language concepts from the unit test extension

```
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  } main (function)

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    assert(0) times2(21) == 42;
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  int8_t times2(int8_t a) {
    return 2 * a;
  } times2 (function)
}
```

Asset Statements check conditions; they are restricted to be used only in test cases.

- The same test, but now using additional language concepts from the unit test extension

```
module UnitTestDemo from cdesignpaper.unittest imports nothing {

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    return test testMultiply;
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    assert(0) times2(21) == 42;
  } testMultiply(test case)

  int8_t times2(int8_t a) {
    return 2 * a;
  } times2 (function)
}
```

A special expression that executes tests, and evaluates to the number of failed tests (which is then returned to the OS here)

- The unit testing extensions are implemented in separate language module.

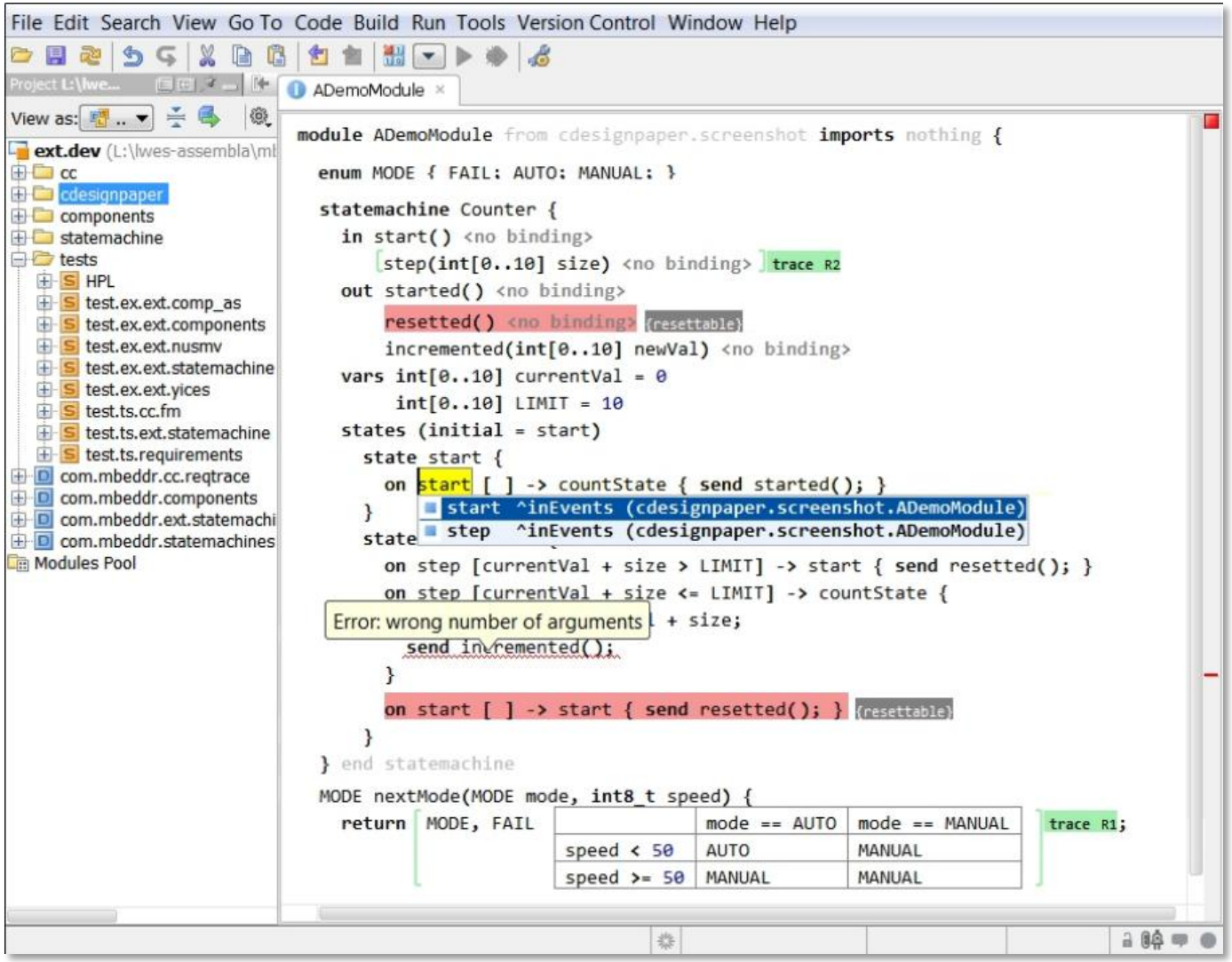
- The constructs become available to programmers only if they import the respective language module into their program

- This keeps the overall language clean -- a precondition for building extensions targetting different audiences.

# mbeddr C Approach

# An extensible C with support for formal methods, requirements and PLE.

# IDE for Everything



# A debugger for all of that

- The Debugger debugs the code on the level of the extensions!

- When defining new language concepts, language developers also specify how these concepts should be debugged.

# SDK for building your own Language Extensions!

- This SDK is essentially MPS ☺, plus some custom documentation.

# IDE for Everything

JetBrains

# MPS

Open Source

Language Workbench

- Apache 2.0
- Available at http://jetbrains.com/mps

# Challenges

## in embedded software development

# Abstraction without Runtime Cost

- Abstractions are important to write maintainable and analyzable software; however,
- Abstractions should not incur runtime overhead (or at least as little as possible)

# C considered unsafe

- void pointers are evil
- standards like MISRA-C prohibit certain constructs from being used in many organizations

# Program Annotations

- Things like physical units, value ranges, or access patterns to data structures are often defined outside the code program in some kind of XML
- The C type checker doesn't know about them, a separate checker is used --- cumbersome!

# Static Checks and Verification

- Model Checking, SAT solving etc. are important to „proof" the correctness of programs, however,
- it is expensive to do on C code since C's abstractions are too low-level

# Product Lines and Requirement Traces

- Trace links from code (or other implementation artifacts) back to requirements must be supported
- Product Line Variability must be handled in a more maintainable way than #ifdefs

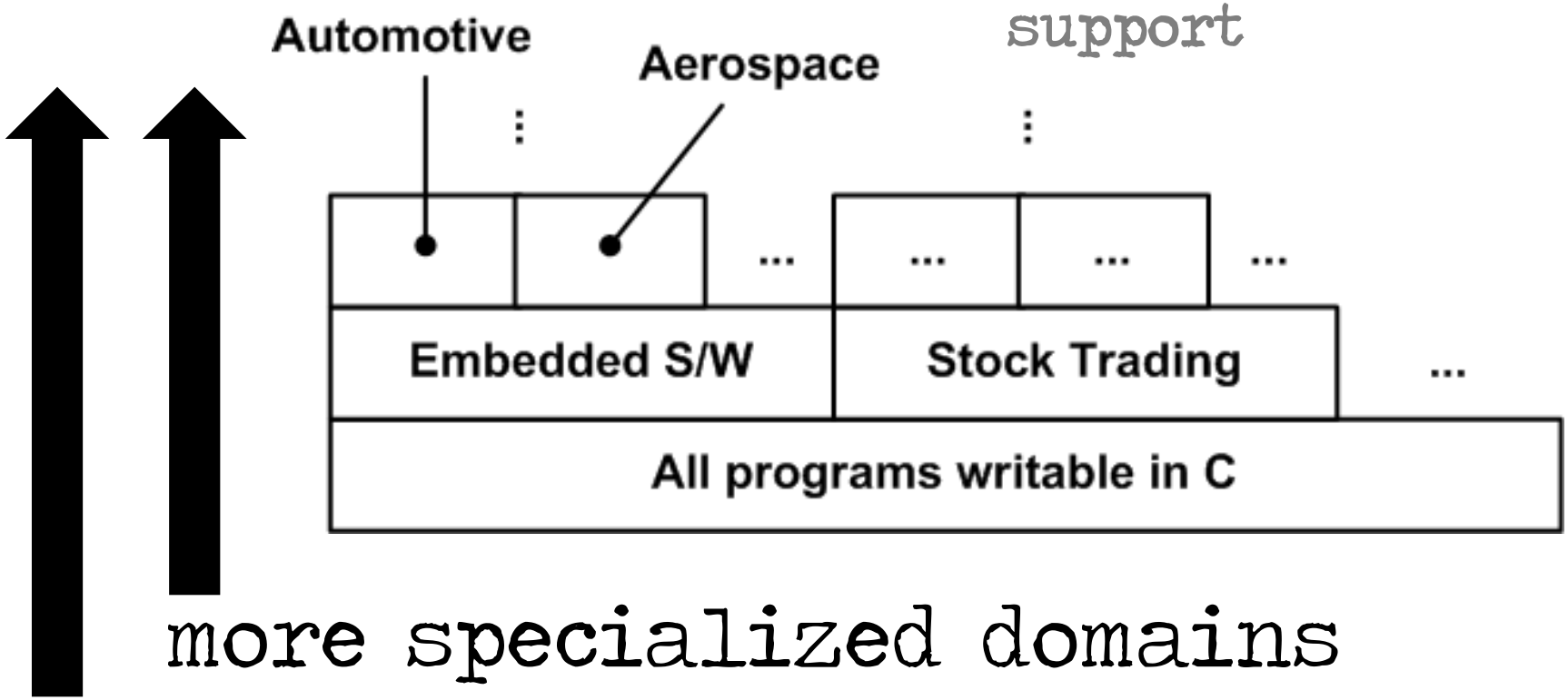
# Separate, hard to integrate Tools

- Modeling tools don't integrate well with each other, or with manually written code
- Modeling tools aren't really extensible, making them hard to adapt to specific domains

# mbeddr C Solution Philosophy

# Extension

- Domains can be seen as specializations of others. Each may require specialized language support

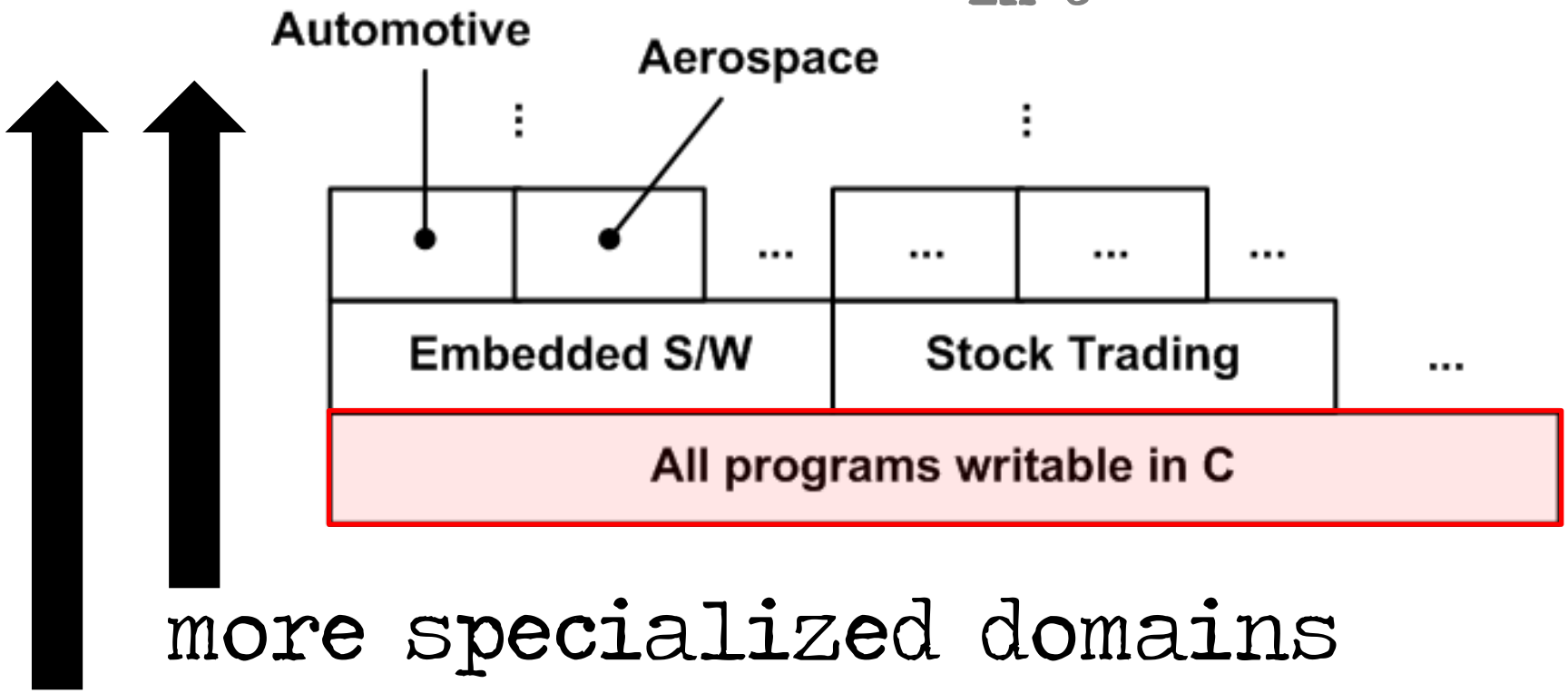



more specialized domains

more specialized languages

# Extension

- There is a general domain the encompasses all programs writable in C

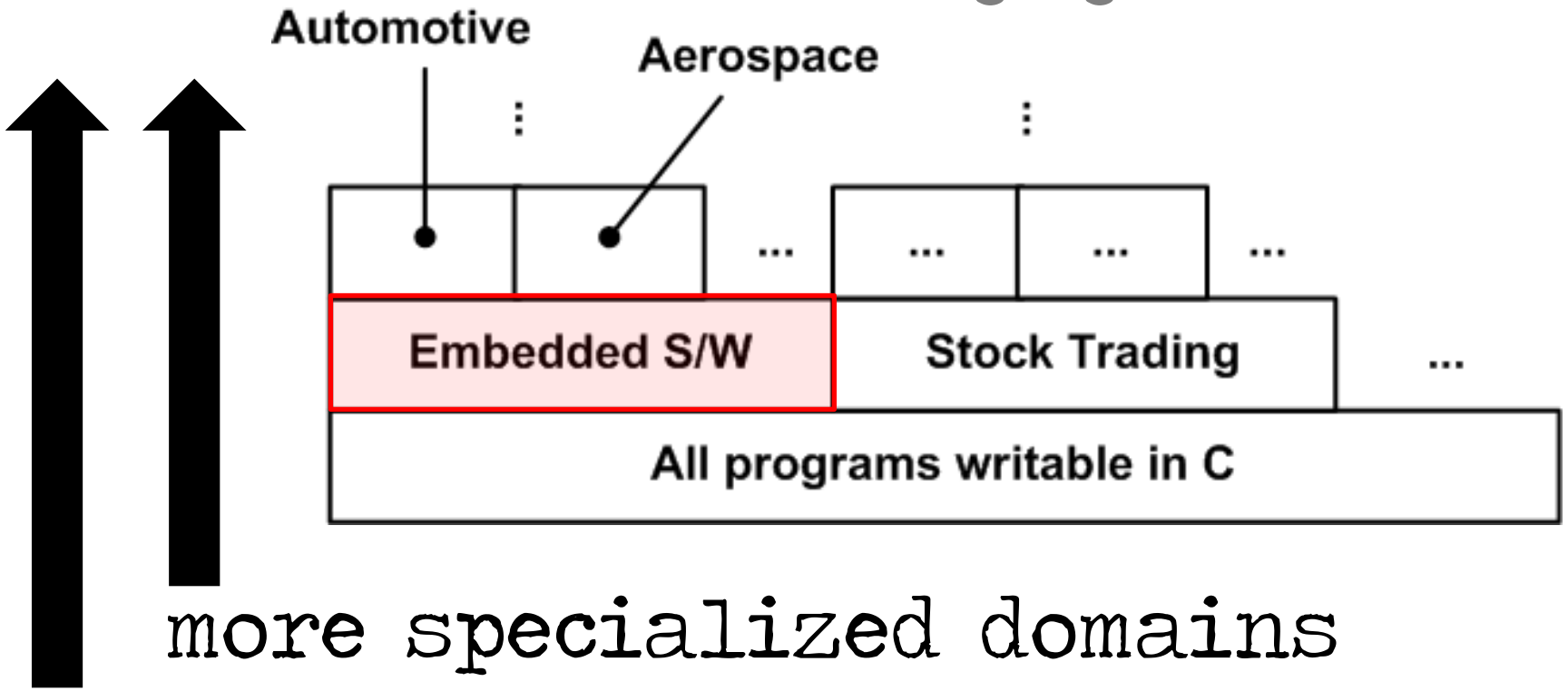



more specialized domains

more specialized languages

# Extension

- Embedded software is a specialzation of C -- requiring special language abstractions

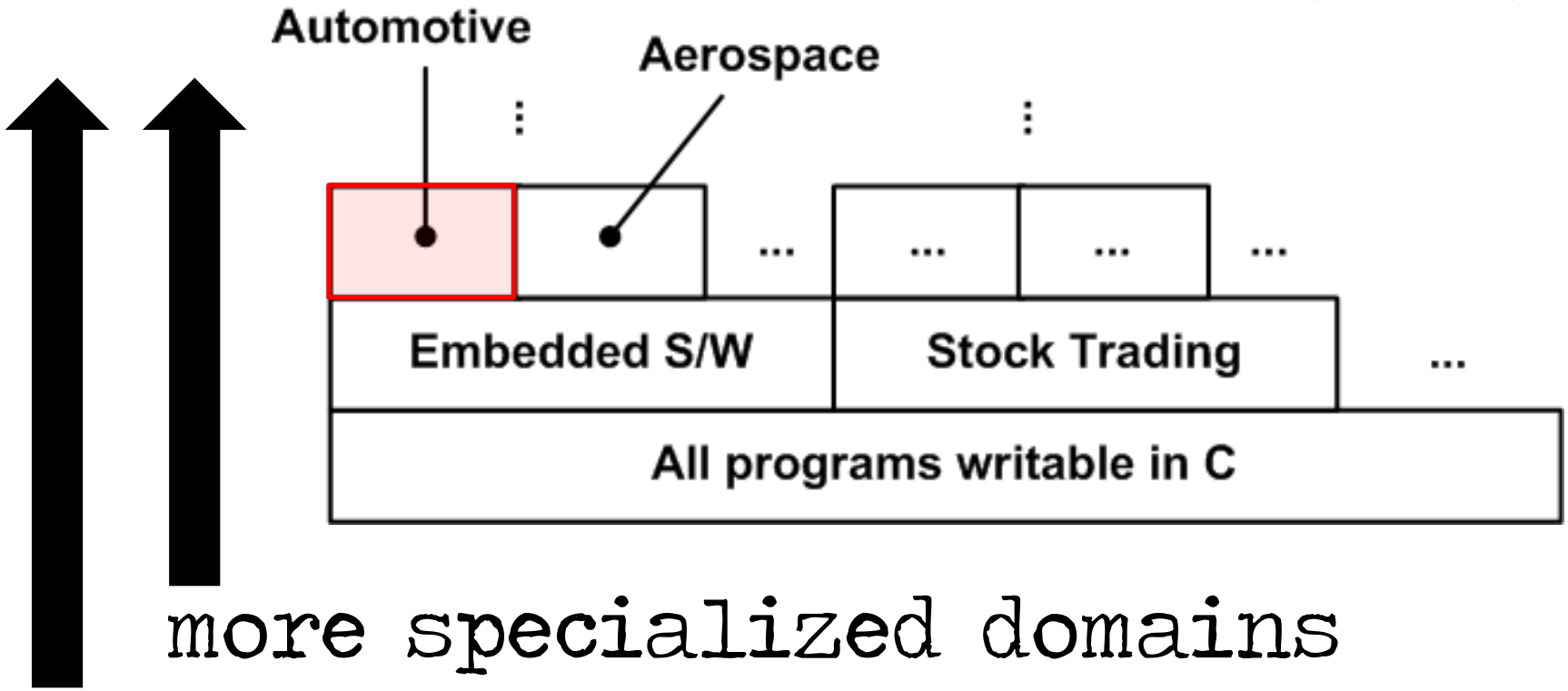



more specialized domains

more specialized languages

# Extension

- Automotive or Aerospace are subsequent specializations … ad infinitum, in principle.




more specialized domains

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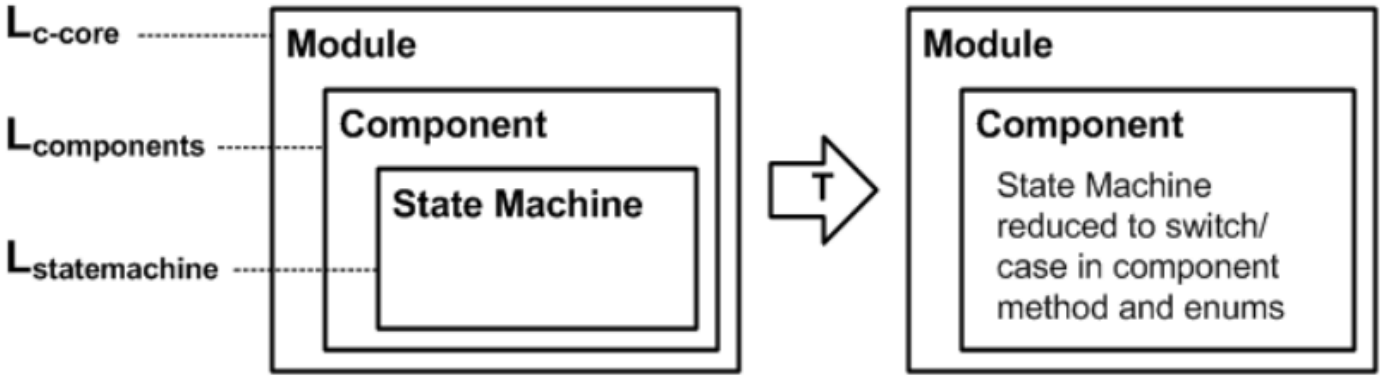
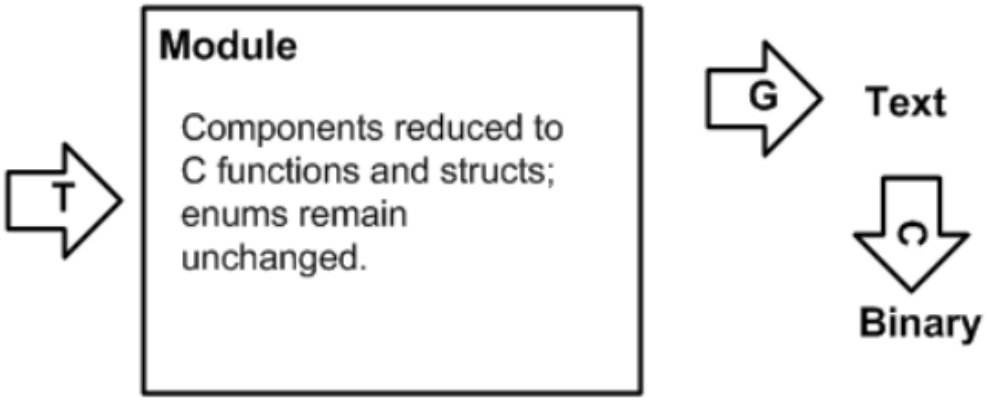
# Incremental Trafo




- Assume we have a module which contains a components which in turn contains a state machine. How is this compiled?



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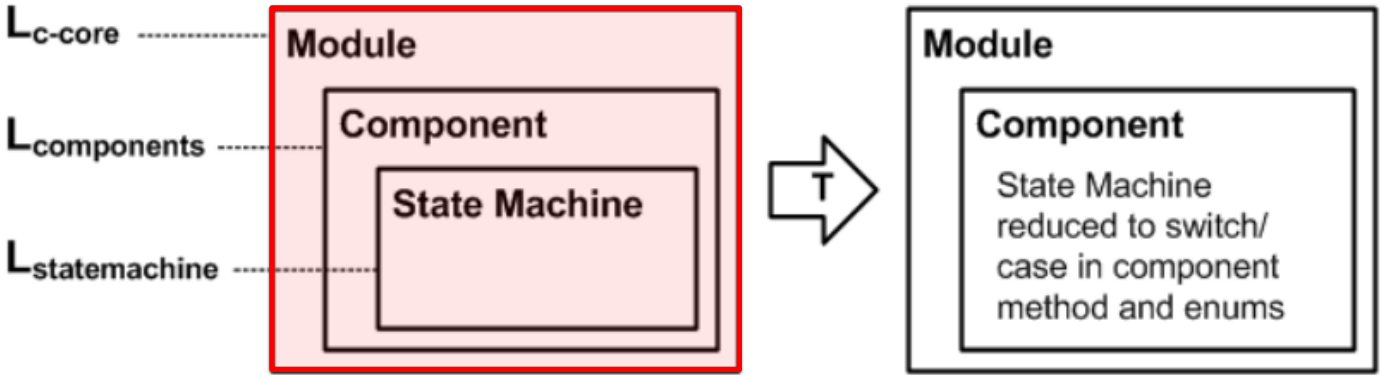


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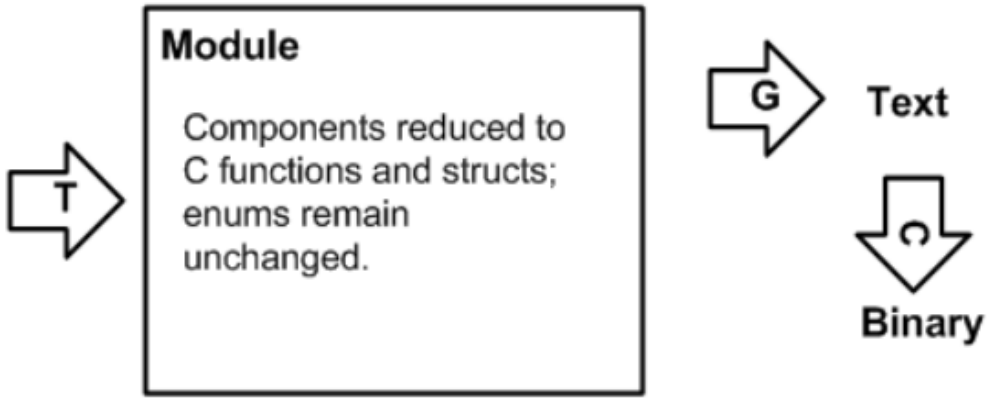

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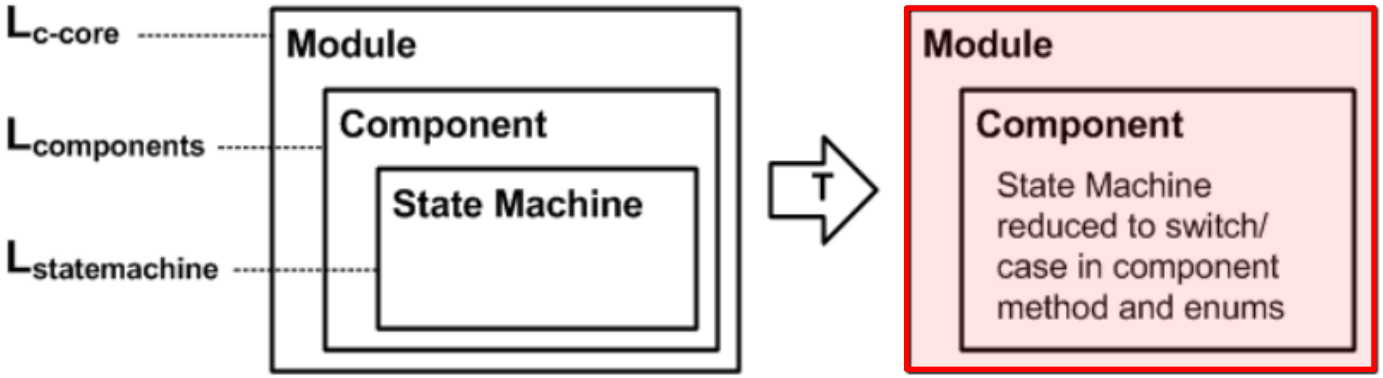
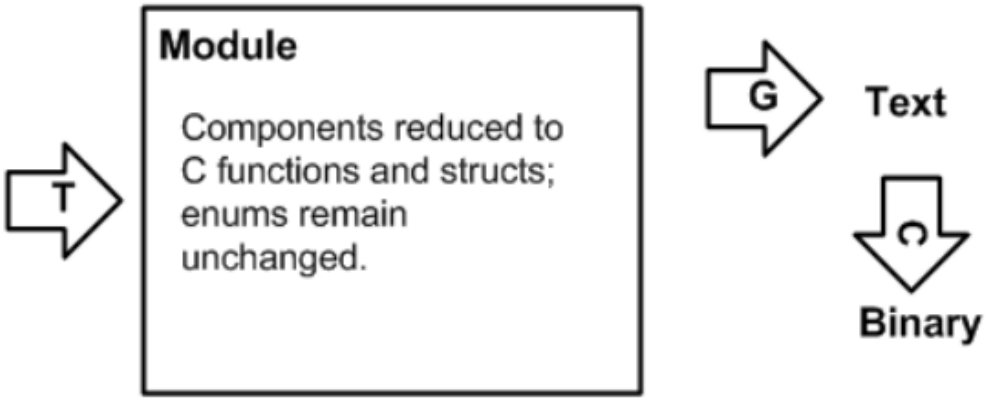



- In the first step, the state machine is reduced to a component operation that contains e.g. the usual switch/ case way of implementing a SM



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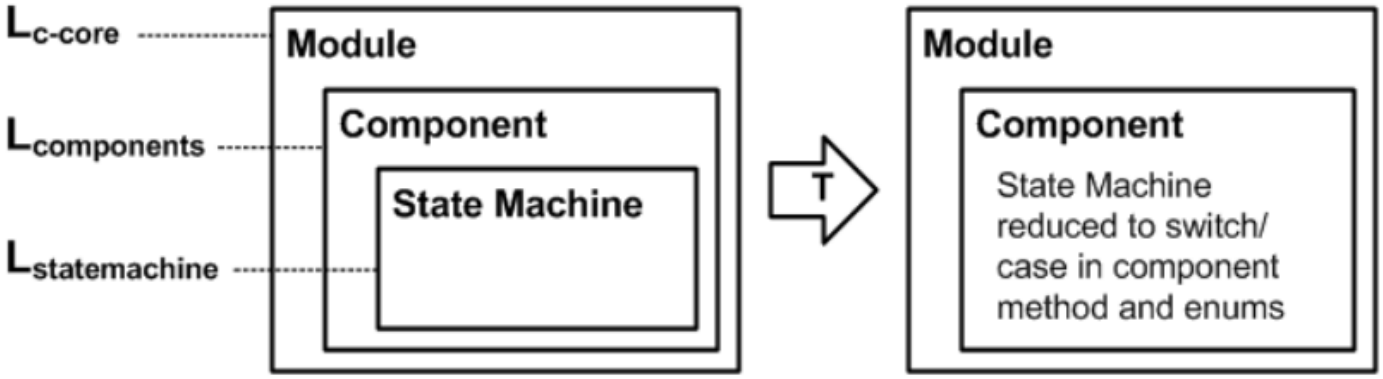
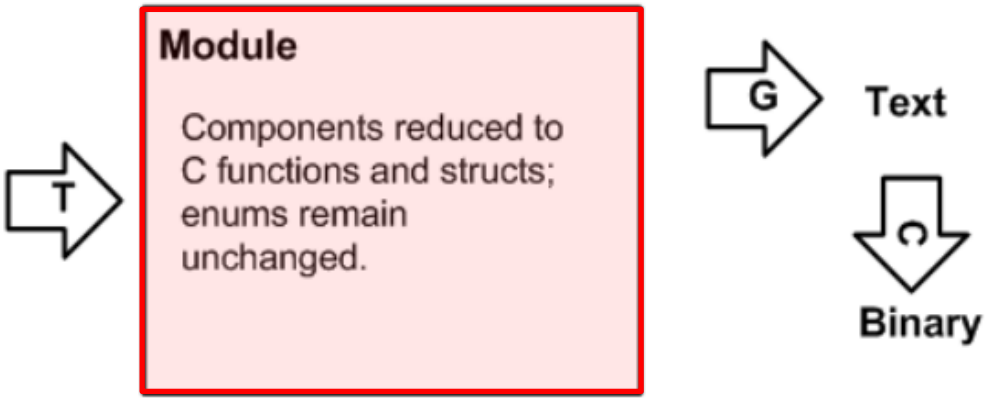



- In the next step, the component is reduced to a bunch of normal C methods; the contains switch /case statement just remains unchanged.



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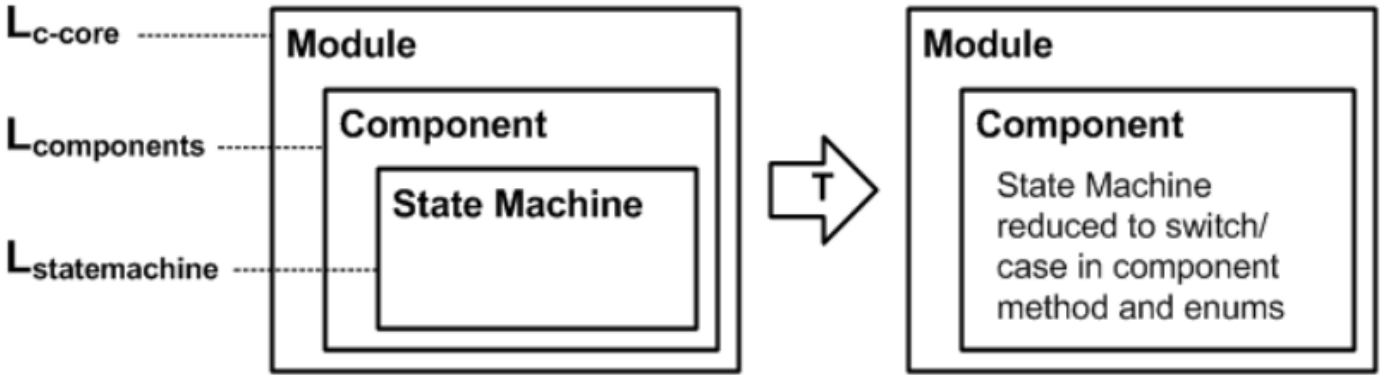
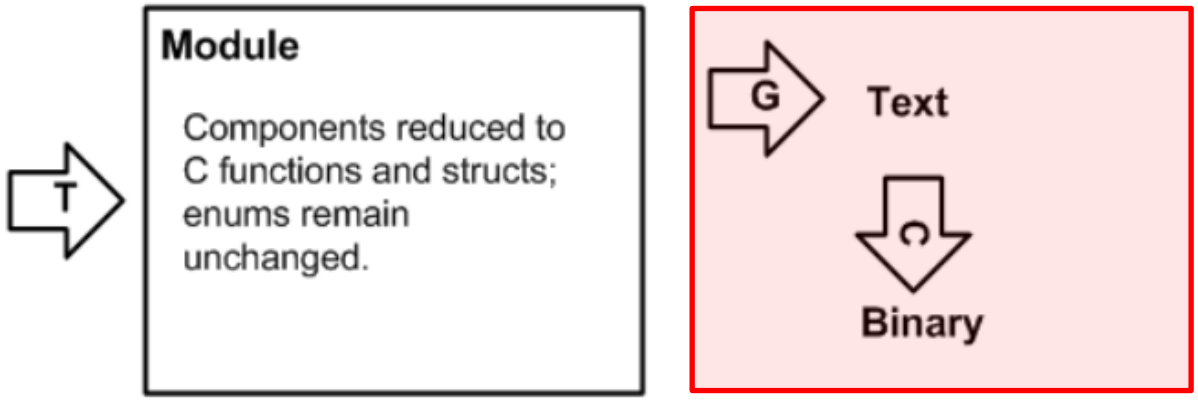



- Finally, we generate text from the C program and feed it into a regular compiler, such as GCC. mbeddr uses incremental reduction!

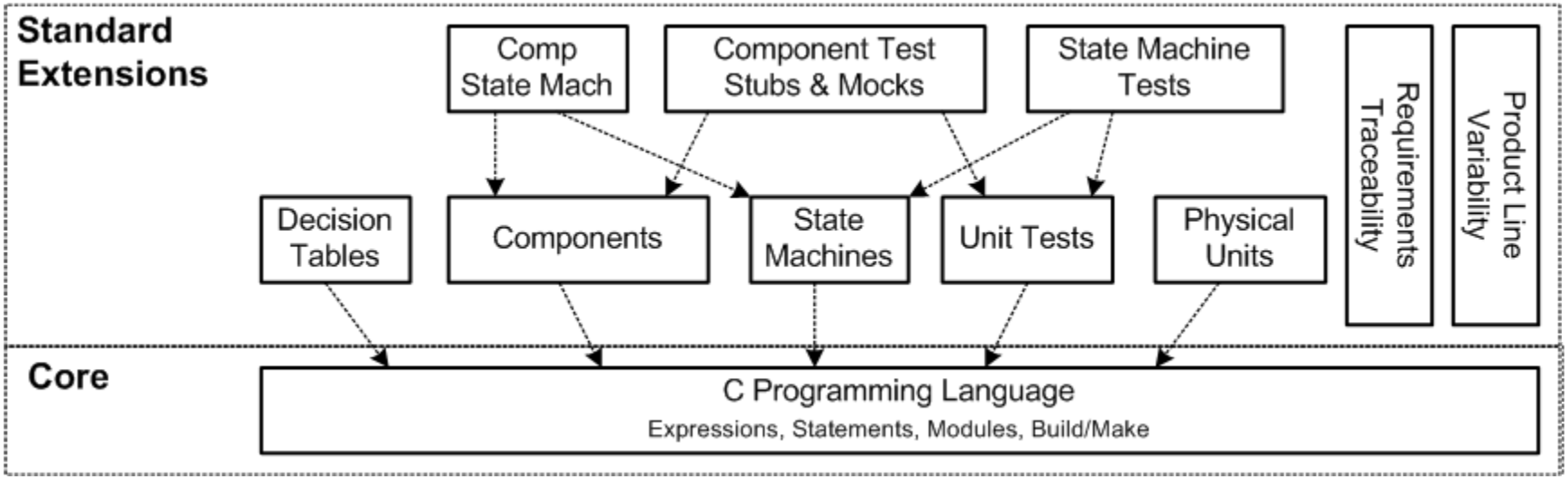


# Language Extension

- The core contains all of C plus a couple of utilities such as namespaces, closures, real boolean types and integration with make.
- A few changes have been made relative to standard C -- these are clearly explained in the docs.
- It is designed to be extensible by users, e.g. it is simple to provide an integration with a custom build infrastructure

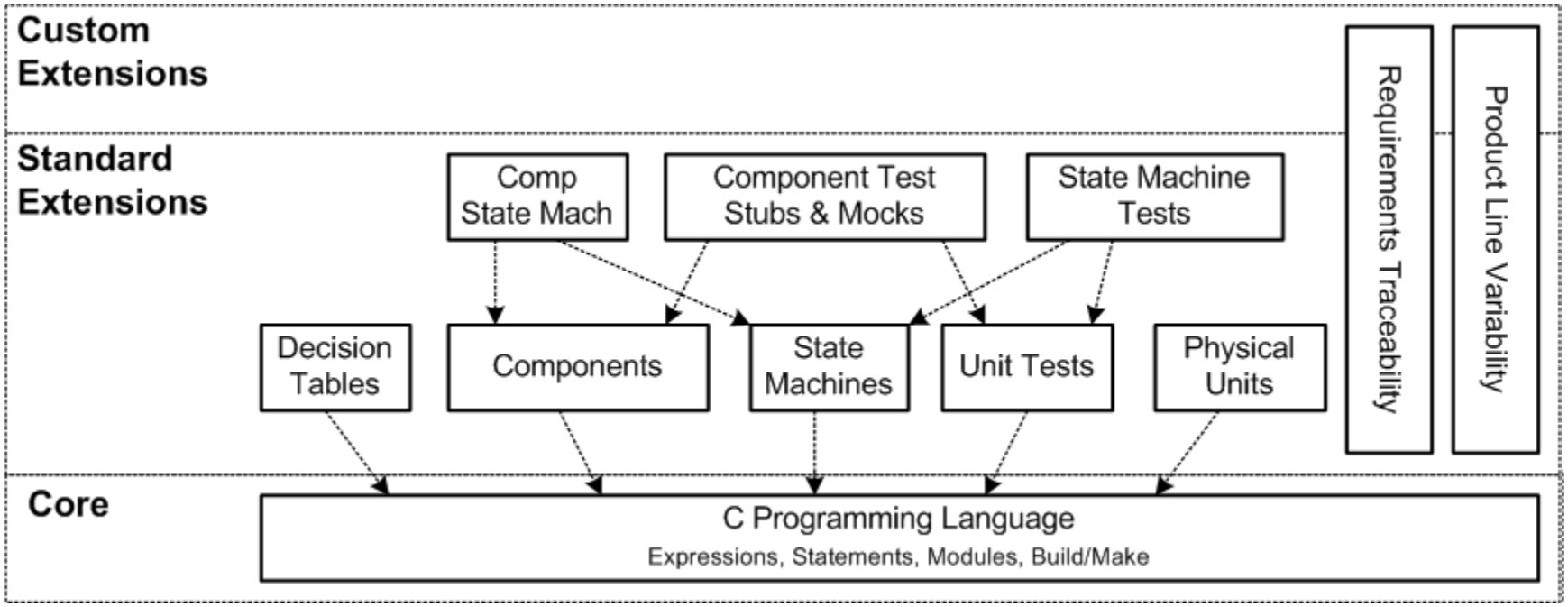
# Language Extension

- These standard extensions are intended to be useful by many embedded software proejects. Most of them will become Open Source during 2012



# Language Extension

- The SDK lets users build their own language extensions in a modular way -- without changing the existing languages, and independent of other extensions.



# Subset of Available Extensions

# All of C (cleaned-up)

- no preprocessor (better replacements!), modules/namespaces, unit tests, C99 primitive types required, booleans, binary literals, function references, closures

```
module Calculator from cdesignpaper.helloWorld imports nothing {

  exported int8_t add(int8_t x, int8_t y) {
    return x + y;
  } add (function)

  exported int8_t multiply(int8_t x, int8_t y) {
    return x * y;
  } multiply (function)
}
```

```
module HelloWorld from cdesignpaper.helloWorld imports Calculator {

  int32_t main(int32_t argc, int8_t*[ ] argv) {
    return add(2, 2) + multiply(10, 2);
  } main (function)
}
```

modules

export instead of header

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module Calculator from cdesignpaper.helloWorld imports nothing {

  exported int8_t add(int8_t x, int8_t y) {
    return x + y;
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    return x * y;
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}
```

module imports

```
module HelloWorld from cdesignpaper.helloWorld imports Calculator {

  int32_t main(int32_t argc, int8_t*[ ] argv) {
    return add(2, 2) + multiply(10, 2);
  } main (function)
}
```

# Retargettable Build Integration

```
Build Configuration for model MutiBot_Test
------------------------------------------------

Target Platform:
  desktop
    compiler: gcc
    compiler options: -std=c99
    debug options: -g

Configuration Items
  reporting: printf
  components: no middleware

Binaries
  executable MultiBotTest isTest: true {
    used libraries
      << ... >>
    included modules
      Driver
      TestDriveTrain
      EcRobotAPI
      Messages
      TestOrienter
      DriveTrain
      Orienter
  }
```

```
Target Platform:
  lego
    oil file: ATMEL_AT91SAM7S256
    path to ecrobot.mak: /opt/lego/nxtOSEK/ecrobot/
```

```
Build Configuration for model MutiBot_Test
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Target Platform:
  desktop
    compiler: gcc
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```

```
Target Platform:
  lego
    oil file: ATMEL_AT91SAM7S256
    path to ecrobot.mak: /opt/lego/nxtOSEK/ecrobot/
```

Example: different target used for generating lego NXT Osek make files (special format)

# Native Support for Unit Testing and Logging

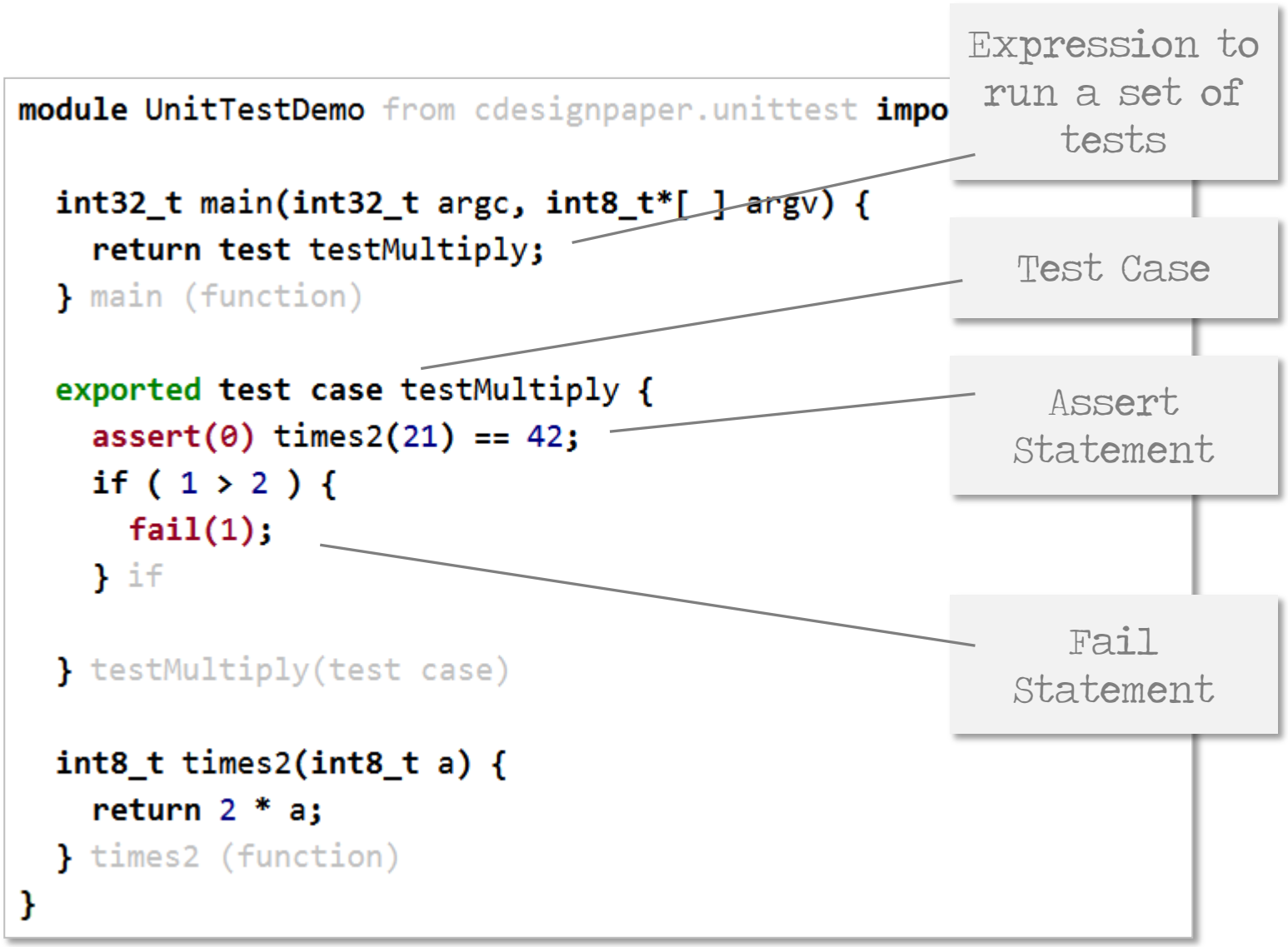
```
module UnitTestDemo from cdesignpaper.unittest imports nothing {

  int32_t main(int32_t argc, int8_t*[ ] argv) {
    return test testMultiply;
  } main (function)

  exported test case testMultiply {
    assert(0) times2(21) == 42;
    if ( 1 > 2 ) {
      fail(1);
    } if

  } testMultiply(test case)

  int8_t times2(int8_t a) {
    return 2 * a;
  } times2 (function)
}
```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if ( 1 > 2 ) {
fail(1);
} if
} testMultiply(test case)
int8_t times2(int8_t a) {
return 2 * a;
} times2 (function)
}
Expression to run a set of tests
Test Case
Assert Statement
Fail Statement

```
module ARealHelloWorld from cdesignpaper.helloWorld imports nothing {

  message list HelloWorldMessages {
    INFO hello(string name) active: Hello World
    ERROR wrongNumberOfArguments(int8_t expected, int8_t actual) active: Wrong number of Arguments
  }

  int32_t main(int32_t argc, int8_t*[ ] argv) {
    report(0) HelloWorldMessages.wrongNumberOfArguments(1, argc) {
      if ( argc != 1 ) {
        report;
        return 1;
      } if
    };
    report(0) HelloWorldMessages.hello(argv[0]) on/if;
    return 0;
  } main (function)
}
```

```
message list HelloWorldMessages {
  INFO hello(string name) active: Hello World
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  }

  int32_t main(int32_t argc, int8_t*[ ] argv) {
    report(0) HelloWorldMessages.wrongNumberOfArguments(1, argc) {
      if ( argc != 1 ) {
        report;
        return 1;
      } if
    };
    report(0) HelloWorldMessages.hello(argv[0]) on/if;
    return 0;
  } main (function)
}
```

Message Definitions with ID, arguments and explaining text

Various forms of report statements to report messages. Translated differently dependending on the target platform

```
message list HelloWorldMessages {
  INFO hello(string name) active: Hello World
  ERROR wrongNumberOfArguments(int8_t expected, int8_t actual) inactive:
}
```

Messages can be deactivated --- no reporting, zero overhead!

Components
Interfaces
Contracts
Instances
Mocks & Stubs

```
exported c/s interface Orienter on contract error MultibotMessages.prePostconditionFailed {
  int16_t heading()
    post(0) result >= 0 && result <= 359
  void orientTowards(int16_t heading, uint8_t speed, DIRECTION dir)
    pre(0) heading >= 0 && heading <= 359
}
```

```
exported component OrienterImpl extends nothing {
  ports:
    provides Orienter orienter
    requires EcRobot_Compass compass
    requires EcRobot_Motor motorLeft
    requires EcRobot_Motor motorRight
  contents:
    field int16_t[5] headingBuffer

    void orienter_orientTowards(int16_t heading, uint8_t speed, DIRECTION dir) <-
        op orienter.orientTowards {
      int16_t currentDir = compass.heading();
      if ( dir == COUNTERCLOCKWISE ) {
        motorLeft.set_speed(-1 * ((int8_t) speed));
        motorRight.set_speed(((int8_t) speed));
        while ( currentDir != heading ) { currentDir = compass.heading(); } while
      } else {
        motorLeft.set_speed(((int8_t) speed));
        motorRight.set_speed(-1 * ((int8_t) speed));
        while ( currentDir != heading ) { currentDir = compass.heading(); } while
      } if
      motorLeft.stop();
      motorRight.stop();
    }

    int16_t orienter_heading() <- op orienter.heading {
      return compass.heading();
    }
}
```

```
exported c/s interface Orienter on contract error MultibotMessages.prePostconditionFailed {
  int16_t heading()
    post(0) result >= 0 && result <= 359
  void orientTowards(int16_t heading, uint8_t speed, DIRECTION dir)
    pre(0) heading >= 0 && heading <= 359
}
```

Interface with Operations

```
exported component OrienterImpl extends nothing {
  ports:
    provides Orienter orienter
    requires EcRobot_Compass compass
    requires EcRobot_Motor motorLeft
    requires EcRobot_Motor motorRight
  contents:
    field int16_t[5] headingBuffer

    enter_orientTowards(int16_t heading, uint8_t speed, DIRECTION
    rienter.orientTowards {
    t currentDir = compass.heading();
    ir == COUNTERCLOCKWISE ) {
    rLeft.set_speed(-1 * ((int8_t) speed));
    rRight.set_speed(((int8_t) speed));
    e ( currentDir != heading ) { currentDir = compass.heading(); } while
    {
      motorLeft.set_speed(((int8_t) speed));
      motorRight.set_speed(-1 * ((int8_t) speed));
      while ( currentDir != heading ) { currentDir = compass.heading(); }
    } if
    eft.stop();
    ight.stop();


    orienter_heading() <- op orienter.heading {
    compass.heading();
```

Optionally with pre- and post conditions --- automatically enforced in every implementing component

Instantiatable, stateful components that provide and require ports

Components implement operations of provided ports

Optional overhead-free translation to plain C - no polymorphism

```
exported test case testDriveTrain {
  initialize instances;
  assert(0) dt.currentSpeed() == 0;
  dt.driveContinouslyForward(50);
  dt.stop();
  validate mock motorLeft;
  validate mock motorRight;
} testDriveTrain(test case)
```

```
instance configuration instances extends nothing {
  instances:
  instance MotorLeftMock motorLeft
  instance MotorRightMock motorRight
  instance DriveTrainImpl driveTrain
  instance EcUtil util
  connectors:
  connect driveTrain.motorLeft to motorLeft.motor
  connect driveTrain.motorRight to motorRight.motor
  connect driveTrain.util to util.util
  adapter:
  << ... >>
}
```

```
mock component MotorLeftMock {
  report messages: true
  ports:
    provides EcRobot_Motor motor
  expectations:
    total no. of calls is 2
    sequence {
      0: motor.set_speed {
          0: parameter speed: speed == 50
        }
      1: motor.stop
    }
}
```

```
mock component MotorRightMock {
  report messages: true
  ports:
    provides EcRobot_Motor motor
  expectations:
    total no. of calls is 2
    sequence {
      0: motor.set_speed {
          0: parameter speed: speed == 50
        }
      1: motor.stop
    }
}
```

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exported test case testDriveTrain {
  initialize instances;
  assert(0) dt.currentSpeed() == 0;
  dt.driveContinouslyForward(50);
  dt.stop();
  validate mock motorLeft;
  validate mock motorRight;
} testDriveTrain(test case)
```

Test case uses mocks; if behavior is different from specified expected behavior, the test fails

```
instance configuration instances extends nothing {
  instances:
  instance MotorLeftMock motorLeft
  instance MotorRightMock motorRight
  instance DriveTrainImpl driveTrain
  instance EcUtil util
  connectors:
  connect driveTrain.motorLeft to motorLeft.motor
  connect driveTrain.motorRight to motorRight.motor
  connect driveTrain.util to util.util
  adapter:
  << ... >>
}
```

Instantiation and port connection

```
mock component MotorLeftMock {
  report messages: true
  ports:
    provides EcRobot_Motor motor
  expectations:
    total no. of calls is 2
    sequence {
      0: motor.set_speed {
          0: parameter speed: speed == 50
        }
      1: motor.stop
    }
}
```

```
mock component MotorRightMock {
  report messages: true
  ports:
    provides EcRobot_Motor motor
  expectations:
    total no. of calls is 2
    sequence {
      0: motor.set_speed {
          0: parameter speed: speed == 50
        }
      1: motor.stop
    }
}
```

Mock components specify expected behavior

# State Machines

# +

# Model Checking

```
verifiable
statemachine Counter {
  in start() <no binding>
     step(int[0..10] size) <no binding>
  out someEvent(int[0..100] x, boolean b) => handle_someEvent
      resetted() => resetted
  vars int[0..100] currentVal = 0
       int[0..100] LIMIT = 10
  states (initial = initialState)
    state initialState {
      on start [ ] -> countState { send someEvent(100, true && false || true); }
    }
    state countState {
      on step [currentVal + size > LIMIT] -> initialState { send resetted(); }
      on step [currentVal + size <= LIMIT] -> countState { currentVal = currentVal + size; }
      on start [ ] -> initialState {  }
    }
} end statemachine
```

in events with arguments

bounded int types for better checking

```
verifiable
statemachine Counter {
  in start() <no binding>
     step(int[0..10] size) <no binding>
  out someEvent(int[0..100] x, boolean b) => handle_someEvent
      resetted() => resetted
  vars int[0..100] currentVal = 0
       int[0..100] LIMIT = 10
  states (initial = initialState)
    state initialState {
      on start [ ] -> countState { send someEvent(100, true && f
    }
    state countState {
      on step [currentVal + size > LIMIT] -> initialState { send resetted(); }
      on step [currentVal + size <= LIMIT] -> countState { currentVal = currentVal + size; }
      on start [ ] -> initialState {  }
    }
} end statemachine
```

Out events with optional bindings to functions

Statemachine-local variables

States with entry and exit actions

Transition using C expressions as guards

Transitions also have transition actions

```
verifiable
statemachine Counter {
  in start() <no binding>
     step(int[0..10] size) <no binding>
  out someEvent(int[0..100] x, boolean b) => handle_someE
      resetted() => resetted
  vars int[0..100] currentVal = 0
       int[0..100] LIMIT = 10
  states (initial = initialState)
    state initialState {
      on start [ ] -> countState { send someEvent(100, tr
    }
    state countState {
      on step [currentVal + size > LIMIT] -> initialState
      on step [currentVal + size <= LIMIT] -> countState
      on start [ ] -> initialState {  }
    }
} end statemachine
```

NuSMV Tool

| Property | Status | Trace Size |
|---|---|---|
| State 'initialState' can be reached | SUCCESS | |
| State 'countState' can be reached | SUCCESS | |
| Variable 'currentVal' is always between its defi... | SUCCESS | |
| Variable 'LIMIT' is always between its defined ... | SUCCESS | |
| State 'initialState' has deterministic transitions | SUCCESS | |
| State 'countState' has deterministic transitions | SUCCESS | |
| Transition 0 of state 'initialState' is not dead | SUCCESS | |
| Transition 0 of state 'countState' is not dead | SUCCESS | |
| Transition 1 of state 'countState' is not dead | SUCCESS | |
| Transition 2 of state 'countState' is not dead | SUCCESS | |
| Condition 'currentVal == 8' can be true | FAIL | 4 |

| Node | Value |
|---|---|
| **State initialState** | |
| LIMIT | 10 |
| currentVal | 0 |
| **State initialState** | |
| in_event: start | star) |
| LIMIT | 10 |
| currentVal | 0 |
| **State countState** | |
| in_event: step | step(8) |
| out_event:someEvent | someEvent(100, true) |
| LIMIT | 10 |
| currentVal | 0 |
| **State countState** | |
| LIMIT | 10 |
| currentVal | 8 |

```
verifiable
statemachine Counter {
  in start() <no bindi
     step(int[0..10] s
  out someEvent(int[0.
      resetted() => re
  vars int[0..100] cur
       int[0..100] LIM
  states (initial = in
    state initialState {
      on start [ ] -> c
    }
    state countState {
      on step [currentV
      on step [currentV
      on start [ ] -> i
    }
} end statemachine
```

A number of default properties for reachability, non-determinism, variable ranges

Additional properties can be described using an abstraction of LTL/CTL

Counter example if a property failes --- clicking on example highlights code in model

Model Checker Results as Tabke

NuSMV Tool

| Property | Status | Trace Size |
|---|---|---|
| State 'initialState' can be reached | SUCCESS | |
| State 'countState' can be reached | SUCCESS | |
| Variable 'currentVal' is always between its defi... | SUCCESS | |
| Variable 'LIMIT' is always between its defined ... | SUCCESS | |
| State 'initialState' has deterministic transitions | SUCCESS | |
| State 'countState' has deterministic transitions | SUCCESS | |
| Transition 0 of state 'initialState' is not dead | SUCCESS | |
| Transition 0 of state 'countState' is not dead | SUCCESS | |
| Transition 1 of state 'countState' is not dead | SUCCESS | |
| Transition 2 of state 'countState' is not dead | SUCCESS | |
| Condition 'currentVal == 8' can be true | FAIL | 4 |

| Node | Value |
|---|---|
| **State initialState** | |
| LIMIT | 10 |
| currentVal | 0 |
| **State initialState** | |
| in_event: start | star) |
| LIMIT | 10 |
| currentVal | 0 |
| **State countState** | |
| in_event: step | step(8) |
| out_event:someEvent | someEvent(100, true) |
| LIMIT | 10 |
| currentVal | 0 |
| **State countState** | |
| LIMIT | 10 |
| currentVal | 8 |

# Requirements Tracability

```
requirements HighLevelRequirements
  show traces true

functional Main: Program has to run from the command line ...
  functional Arg2: Argument Count must be 2 ...
    functional FailOtherwise: Otherwise it should return -1 ...
functional Add: The program should return the sum of the two arguments ...
  functional AddFct: Adding should be a separate function for reuse ...
```

```
requirements modules: HighLevelRequirements
module ExampleCode from test.ts.requirements.code imports StrUtil {

  int8_t add(int8_t a, int8_t b) {  trace AddFct
    return a + b;
  } add (function)

  int8_t main(string[ ] args, int8_t argc) {                                  trace Main
    if ( argc == 2 ) {                                                  trace Arg2
      return add(str2int(args[0]), str2int(args[1])) trace Add;
    } else {
      return -1; trace FailOtherwise
    } if
  } main (function)
}
```

```
requirements HighLevelRequirements
  show traces true

functional Main: Program has to run from the command line ...
  functional Arg2: Argument Count must be 2 ...
    functional FailOtherwise: Otherwise it should return -1 .
functional Add: The program should return the sum of the two
  functional AddFct: Adding should be a separate function for
```

Simple way to specify requirements (kind, ID, description)

Alternatively import them from external tool

```
requirements modules:  HighLevelRequirements
module ExampleCode from test.ts.requirements.code imports StrUtil {

  int8_t add(int8_t a, int8_t b) {  trace  AddFct
    return a + b;
  } add (function)

  int8_t main(string[ ] args, int8_t argc) {
    if ( argc == 2 ) {
      return add(str2int(args[0]), str2int(args[1]))
    } else {
      return -1;  trace  FailOtherwise
    } if
  } main (function)
}
```

Requirements traces can be attached to any program element expressed in any language -- no changes to host language necessary

Requirements kind and trace kind can be extended.

```
requirements HighLevelRequirements
  show traces false

functional Main: Program has to run from the command line ...
  functional Arg2: Argument Count must be 2 ...
    functional FailOtherwise: Otherwise it should return -1 ...
functional Add: The program should return the sum of the two arguments ...
  functional AddFct: Adding should be a separate function for reuse ...
```

```
requirements modules: HighLevelRequirements
module ExampleCode from test.ts.requirements.code imports StrUtil {

  int8_t add(int8_t a, int8_t b) {
    return a + b;
  } add (function)

  int8_t main(string[ ] args, int8_t argc) {
    if ( argc == 2 ) {
      return add(str2int(args[0]), str2int(args[1]));
    } else {
      return -1;
    } if
  } main (function)
}
```

And code can also be edited without the traces, if developers prefer that.

# Product Line Variability

```
feature model DeploymentConfiguration
  root ? {
    logging
    test
    valueTest [int8_t value]
  }

configuration model Debug configures DeploymentConfiguration
  root {
    logging
    test
    valueTest [value = 42]
  }

configuration model Production configures DeploymentConfiguration
  root {
    << ... >>
  }
```

Textual Notation for Feature Models

Optional Feature

Configuration Model („intance" of the Feature Model) that selects a set of features

```
Variability from FM: DeploymentConfiguration
Rendering Mode: product line

{!test}
module ApplicationModule from test.ex.cc.fm imports SensorModule {

  {logging}
  message list messages {
    INFO beginningMain() active: entering main function
    INFO exitingMain() active: exitingMainFunction
  }

  exported test case testVar {
    {logging}
    report(0) messages.beginningMain() on/if;
    int8_t x = getSensorValue(1) replace if {test} with 42;
    {logging}
    report(1) messages.exitingMain() on/if;
    assert(2) x == 10 replace if {test} with 42;
    {valueTest}
    int8_t vv = value;
    {valueTest}
    assert(3) vv == 42;
    int8_t ww = 22 replace if {valueTest} with 12 + value;
    {!valueTest}
    assert(4) ww == 22;
    {valueTest}
    assert(5) ww == 54;
  } testVar(test case)

  int32_t main(int32_t argc, string[ ] args) {
    return test testVar;
  } main (function)
}
```

```
feature model DeploymentConfiguration
  root ? {
    logging
    test
    valueTest [int8_t value]
  }

configuration model Debug configures DeploymentConfiguration
  root {
    logging
    test
    valueTest [value = 42]
  }

configuration model Production configures DeploymentConfiguration
  root {
    << ... >>
  }
```

Code contains annotations with boolean expressions over the features in Feature Model

Color depends on expression --- same expression, same color

This page shows the product line mode --- all options in code

```
Variability from FM: DeploymentConfiguration
Rendering Mode: variant rendering config: Debug
module ApplicationModule from test.ex.cc.fm imports {

  message list messages {
    INFO beginningMain() active: entering main function
    INFO exitingMain() active: exitingMainFunction
  }

  exported test case testVar {
    report(0) messages.beginningMain() on/if;
    int8_t x = 42;
    report(1) messages.exitingMain() on/if;
    assert(2) x == 42;
    int8_t vv = value (variant Debug);
    assert(3) vv == 42;
    int8_t ww = 12 + value (variant Debug);
    assert(5) ww == 54;
  } testVar(test case)

  int32_t main(int32_t argc, string[ ] args) {
    return test testVar;
  } main (function)
}
```

```
feature model DeploymentConfiguration
  root ? {
    logging
    test
    valueTest [int8_t value]
  }

configuration model Debug configures DeploymentConfiguration
  root {
    logging
    test
    valueTest [value = 42]
  }

configuration model Production configures DeploymentConfiguration
  root {
    << ... >>
  }
```

Code in the debug configuration --- „everything in"

```
Variability from FM: DeploymentConfiguration
Rendering Mode: variant rendering config: Production
module ApplicationModule from test.ex.cc.fm imports SensorModule {


  exported test case testVar {
    int8_t x = getSensorValue(1);
    assert(2) x == 10;
    int8_t ww = 22;
    assert(4) ww == 22;
  } testVar(test case)

  int32_t main(int32_t argc, string[ ] args) {
    return test testVar;
  } main (function)
}
```

```
feature model DeploymentConfiguration
  root ? {
    logging
    test
    valueTest [int8_t value]
  }

configuration model Debug configures DeploymentConfiguration
  root {
    logging
    test
    valueTest [value = 42]
  }

configuration model Production configures DeploymentConfiguration
  root {
    << ... >>
  }
```

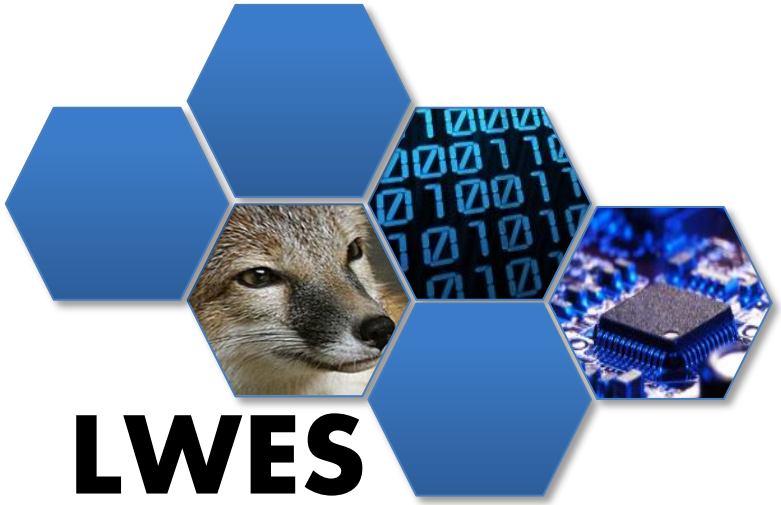
Code in the production configuration --- „everything out"

# Status and Availability

# http://mbeddr.com

- Introduction, Blog, Papers, Code

# Developed in the



**LWES**

**Language Workbenches**
*for* **Embedded Systems**

- Project runs till June 2013
- itemis, fortiss, SICK, Lear

Bundesministerium
für Bildung
und Forschung

gefördert durch das BMBF
Förderkennzeichen 01IS11014

# Core is Open Source (EPL)

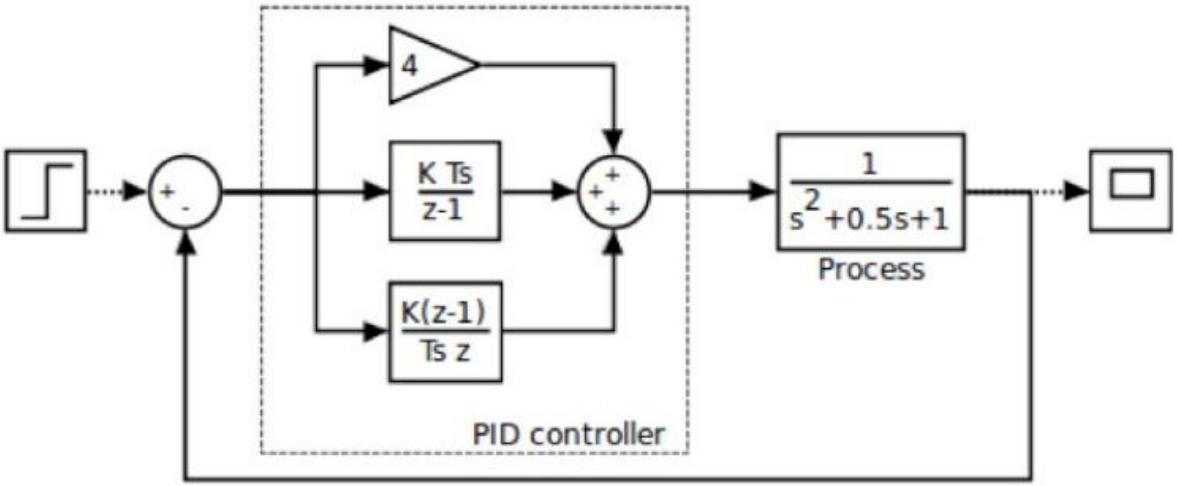
- Eclipse Public License
- Essentually no restrictions regarding commercial use

# Some Extensions will be Open Sourced this year

- We have to finish/stabilize them before we make them available
- Statemachines & Components will certainly be part of the Open Source package

# Custom Extensions and Professional Services by


- Introducing the tool
- Language Definition and Extension
- We're looking for protype customers!




# support for graphical early 2013

- state machines and block diagrams
- integrated with text


# integration in early 2013

- native integration with Eclipse UI
- EMF export already possible today

# mbeddr C

An extensible version of the
C programming language
for Embedded Programming

# http://mbeddr.com

C the Difference - C the Future