目录

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- 软件测试基本概念
- QAC介绍
- Tessy介绍

软件测试定义

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- 软件测试定义
  - 软件测试是为了发现错误而执行程序的过程
  - 软件测试是根据软件开发阶段的规格说明和程序的内部结构而设计一批测试用例，并利用这些测试用例去运行程序，以发现错误的过程

- 软件测试的目的
  - 发现错误；
  - 发现至今未发现的错误；
  - 至今未发现的错误的测试。

软件测试分类

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- 软件测试
  - 测试阶段
    - 单元测试
    - 集成测试
    - 系统测试
    - 回归测试
    - 验收测试
  - 测试技术
    - 白盒测试
    - 黑盒测试
      - 功能测试
        - 逻辑功能测试
        - 界面测试
        - 安装测试
      - 性能测试
        - 一般性能测试
        - 稳定性能测试
        - 负载测试
        - 压力测试
  - 是否运行程序
    - 静态测试
    - 动态测试
  - 其他方法
    - 冒烟测试
    - 随机测试

软件测试技术——静态测试

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- 定义
  - 静态测试技术是不执行程序代码而寻找代码中可能存在的错误或评估程序代码的过程
- 分类
  - 代码审查
  - 代码走查
  - 技术评审（软件需求分析和设计评审）

软件测试技术——动态测试

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- 定义
  - 动态测试是在抽样测试数据上执行程序并分析输出以发现错误的过程。抽样数据必须满足一定的要求。

- 特点
  - 运行代码本身
  - 测试质量依赖测试数据
  - 工作量大
  - 测试过程中涉及到多方面协调工作

静态测试与动态测试

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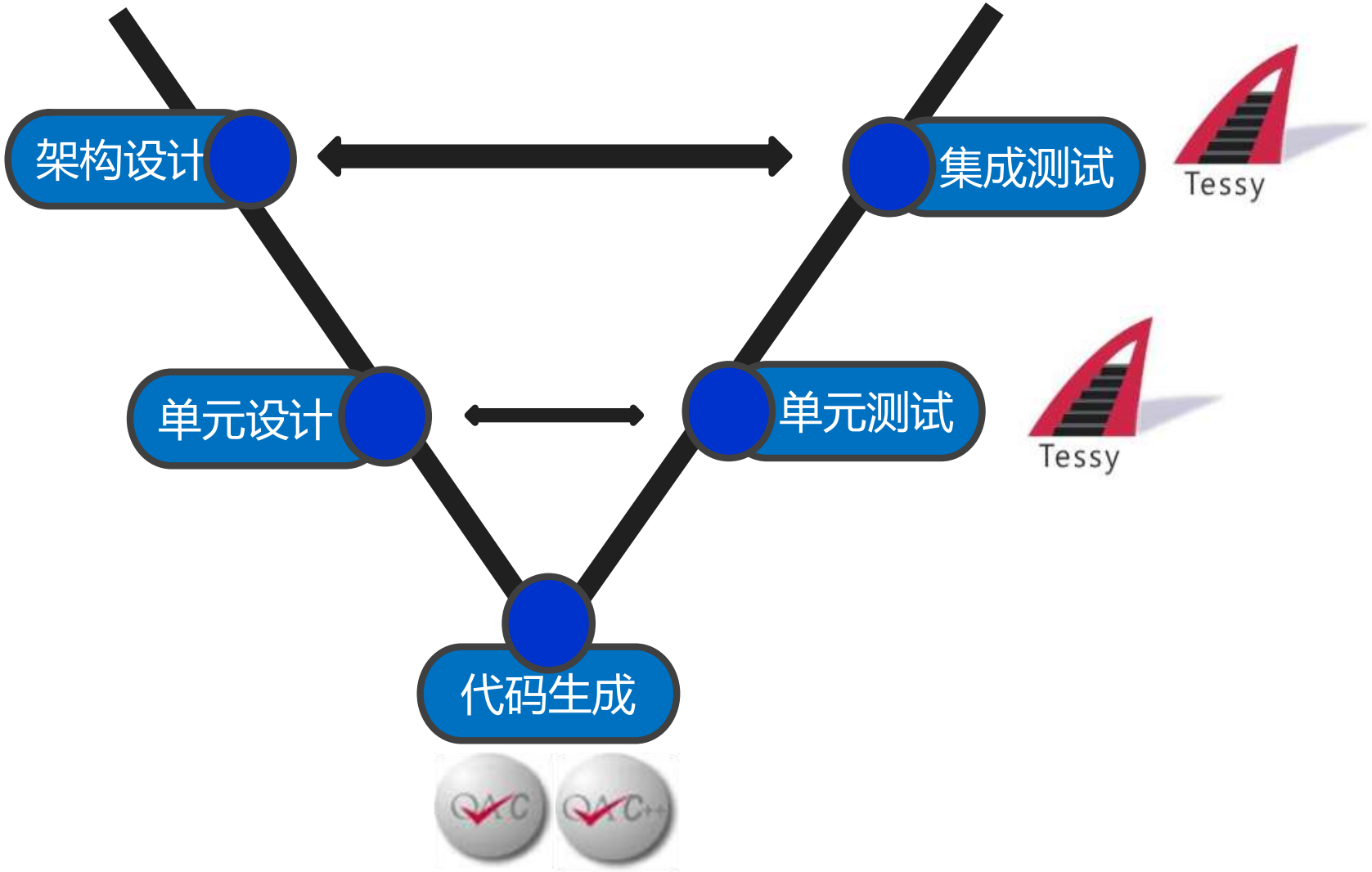
	静态测试	动态测试
出现阶段	• 尽可能早的阶段 • 代码编写过程中 • 不需要执行程序	• 单元测试阶段 • 需要执行程序
主要用户	• 开发人员	• 测试人员
测试性能	• 可靠性、功能性、可用性、效率、**可维护性、可移植性**	• 功能性、可靠性、可用性、效率、可维护性、可移植性
覆盖率	• 100% • 一些预先可确定的数据流分析级别	• 80%-90% • 不可能覆盖所有情况
测试用例	• 不需要，但需要编程规范	• 需要根据需求设计测试用例
自动化率	• **100%**	• 一般情况下为80%-90%

测试流程VS工具



软件测试流程

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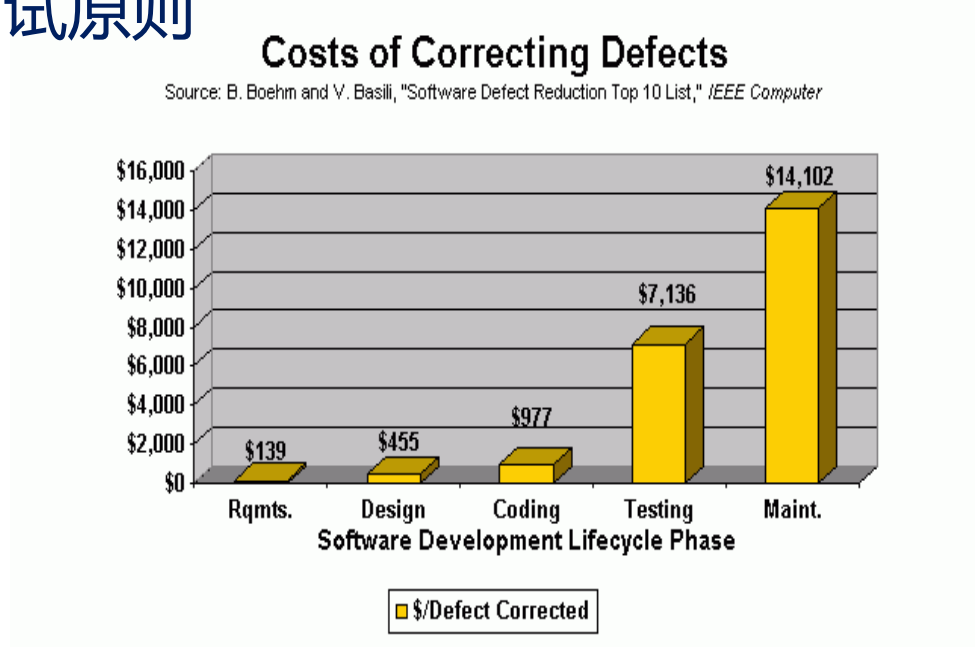
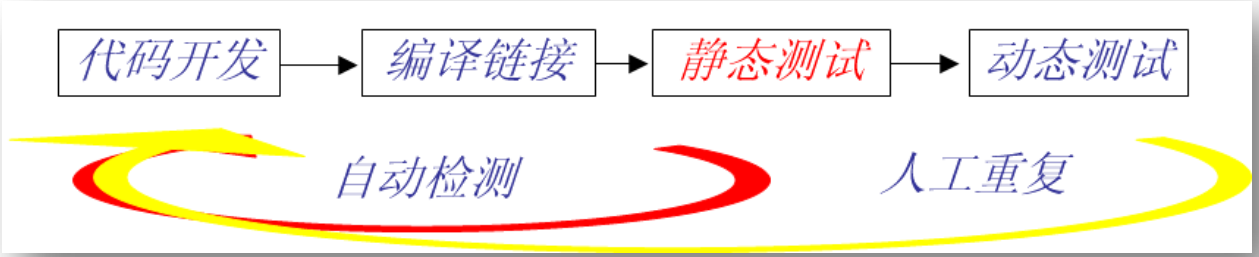
- 企业做软件测试的核心思想
  - 软件的排错成本随着生命周期成指数级别递增
- 核心思想指导下的软件测试原则
  - 尽早测试
  - 连续测试
    - 先静后动
      - 先静态，再动态
    - 由小到大
      - 先单元，再集成
  - 尽量自动
    - 排除测试随意性
      - 测试计划/用例/脚本





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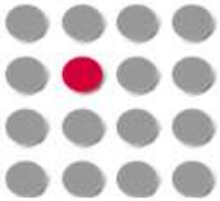
QAC简介



——软件潜在缺陷测试

软件编码常见问题

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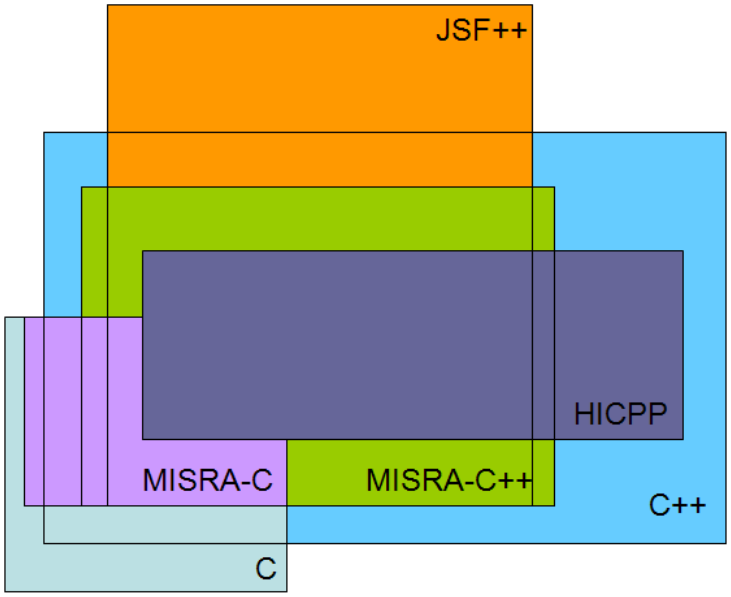
- 编码过程中存在的问题
  - 语法错误
  - 不可移植
  - 经常出现的编程错误
  - 程序复杂
  - 代码风格缺乏一致性
- 采用编码规范的好处
  - 培养高素质的开发人员
  - 开发出高质量源代码
  - 早期就可以避免一些隐含的“bug”

什么是编码规范

- 编码规范是进行编程时，编程语言的使用准则和规范
  - 源代码注释应该使用 /*...*/
  - 汇编语言应该使用宏进行封装
  - 所有变量在使用前必须赋值
  - 不能有不可达的代码
  - 不能使用goto/ continue语句
  - 函数不能调用自身
  - 不能使用#undef
  - ……



MISRA介绍

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- The **M**otor **I**ndustry **S**oftware **R**eliability **A**ssociation
  汽车行业软件可靠性协会

- MISRA C规范的目的
  定义了一个C安全子集，使控制器代码符合汽车行业应用，确保软件安全可靠。

- 在MISRA基础上适当修改就可以形成自己的规范

MISRA C规则示例

- **MISRA C 2004**
  - 21类共142条规则
  - 122条强制规则
  - 20条推荐规则

规则编号及描述

附加说明

代码示例

属于第1类规则的第1条

1011 › [C99] Use of '//' comment.

ISO C99 Language features

REFERENCE - ISO:C99-6.4.9 Comments

The use of // to introduce a comment is a feature of ISO:C99 but is not supported by ISO:C90. In practice it is widely supported by C compilers.

Message 1011 will not be generated if the C++ language extension option is enabled (-ex C++).

```
/*PRQA S 2017,3211,3408 ++*/
    int     p1;    /* Message 1011 */ // because of this comment
```

MISRA-C:2004 Rules applicable to message 1011:

Rule 1.1	All code shall conform to ISO/IEC 9899:1990 C programming language, ISO 9899, amended and corrected by ISO/IEC 9899/COR1:1995, ISO/IEC 9899/AMD1:1995, and ISO/IEC 9899/COR2: 1996192
Rule 2.2	Source code shall only use C-style comments.

QAC/C++工具认证

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- QA-C 、QA-C++ 以及MISRA模块
- 认证: “以符合需求为目标开发安全的软件”
- 可达 IEC 61508 SIL 3级
- 可达 ISO 26262 级别, ASIL D
- 安全手册：描述如何正确使用

QAC性能优异

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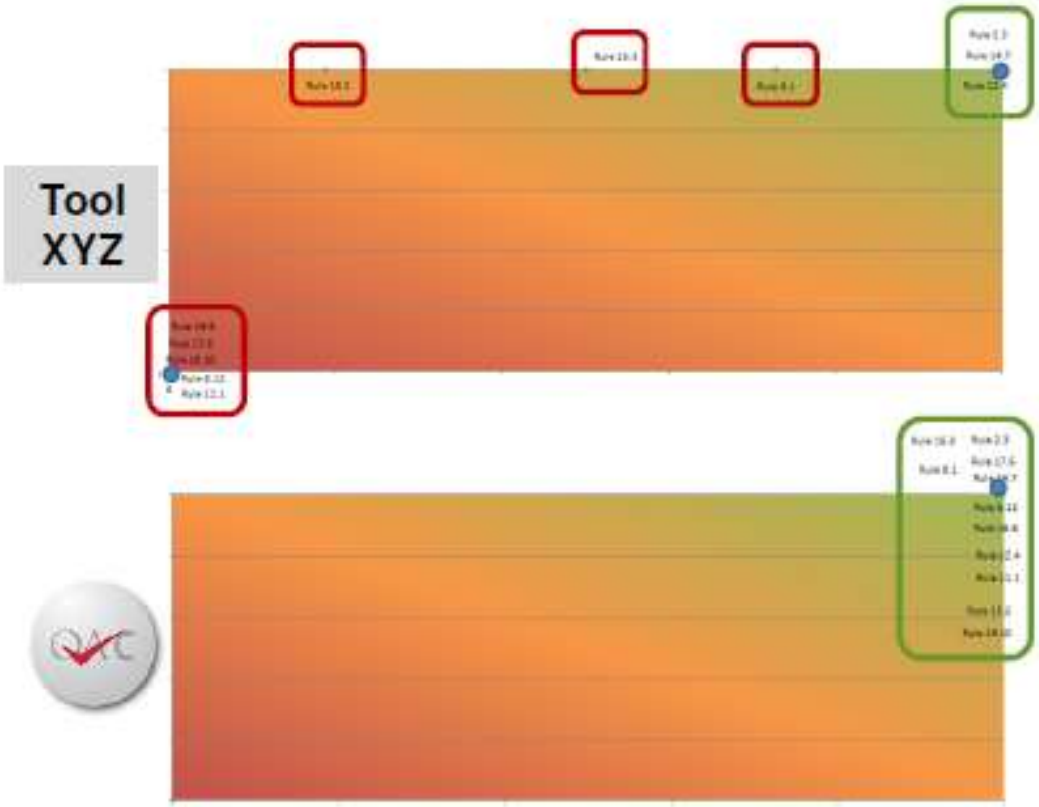
- TERA-Lab
  - X轴表示：误报（由左边至右边递减）
  - Y轴表示：漏报（由下边至上边递减）

The author of the TERA-Labs report observed:

"On paper all the selected tools claimed to provide comprehensive MISRA C compliance checking – but the reality was different."



QAC应用

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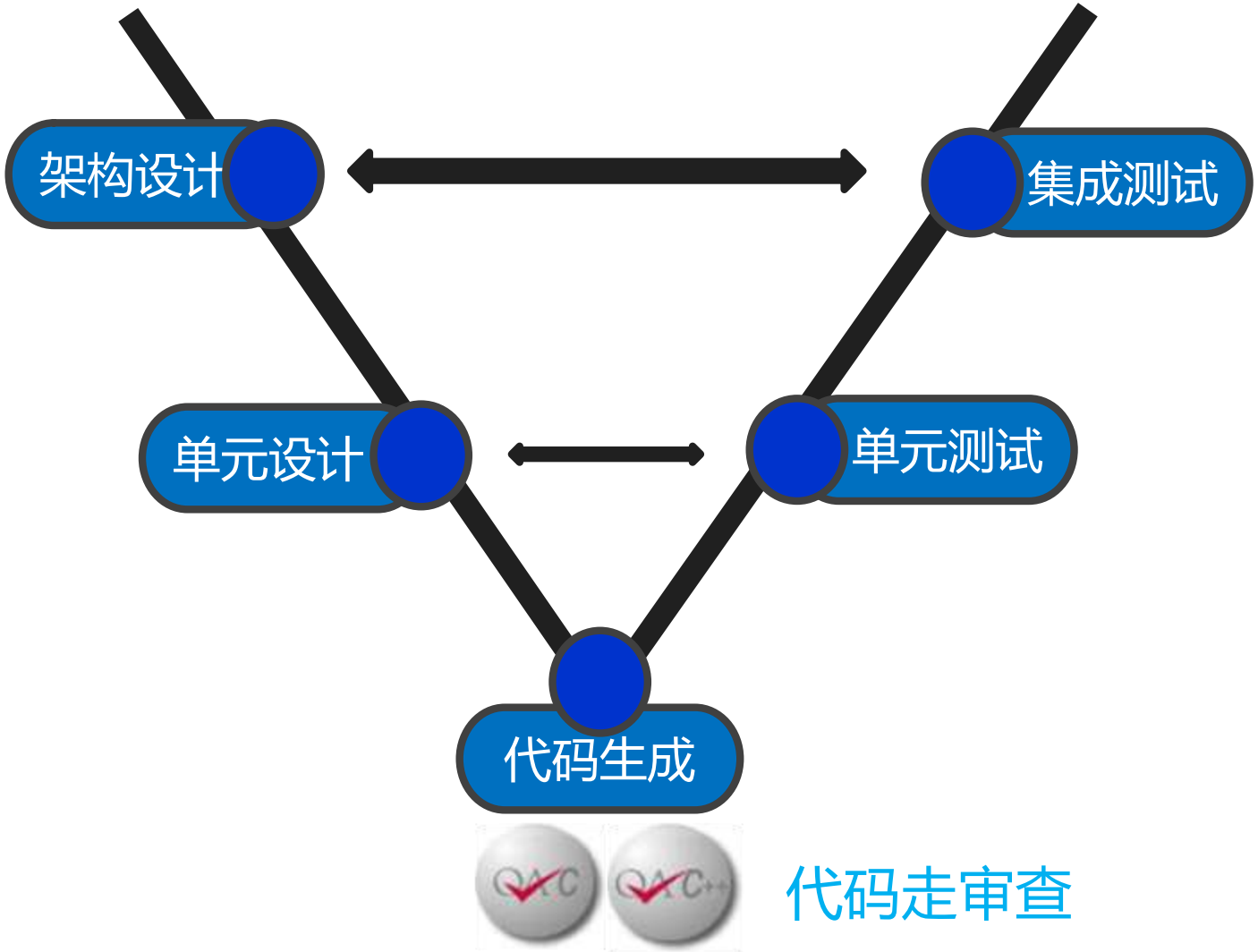

QAC主要功能

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- 代码潜在缺陷/Bug检查
- 编程规则检查
- 代码质量度量
- 代码结构分析

QAC功能介绍(1/8)

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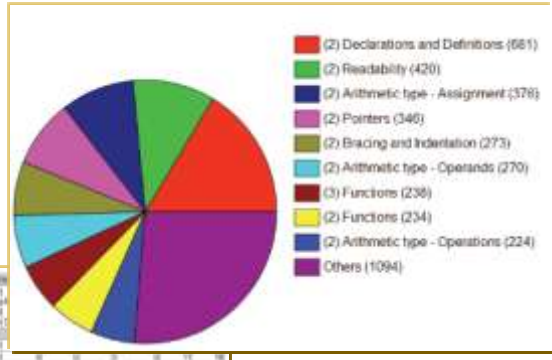
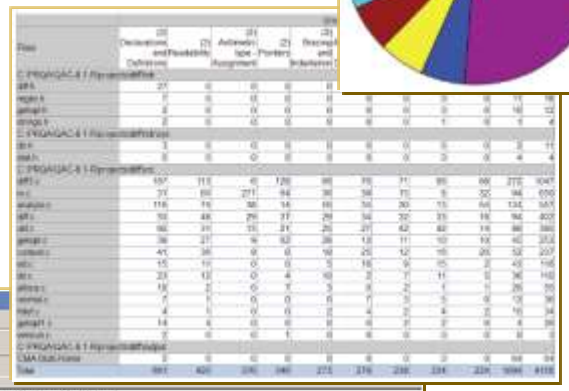
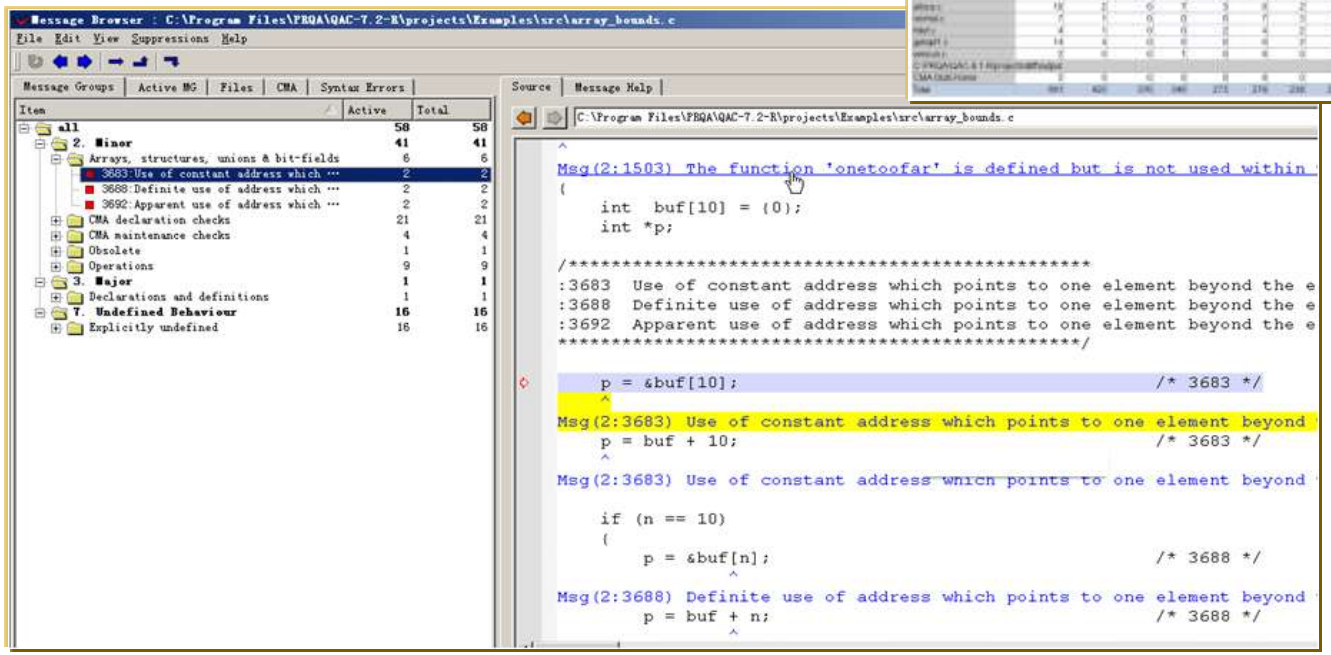
■ 静态测试工具

- ✓ 包含1700条检测点，支持MISRA-C/C90/C99
- ✓ 规则集全面，支持自定义编程规范
- ✓ 操作界面简单易用
- ✓ 可以和目前流行的开发环境集成







QAC功能介绍(2/8)

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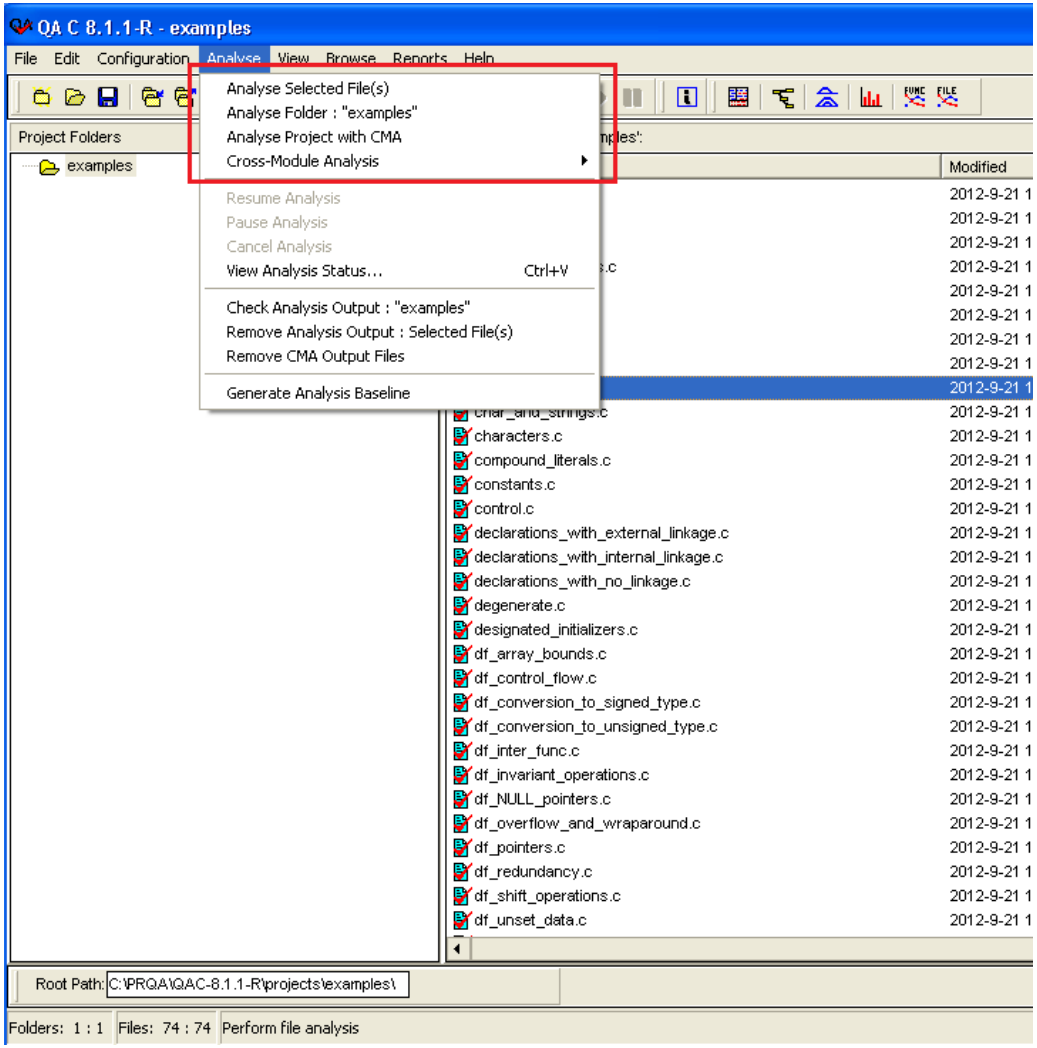
- 分析内容
  - 所选文件
  - 整个文件夹
  - 工程
  - CMA
- 结果
  - 规则检查
  - 代码度量
  - 函数结构
  - 文件关系
  - 统计分析



QAC功能介绍(3/8)

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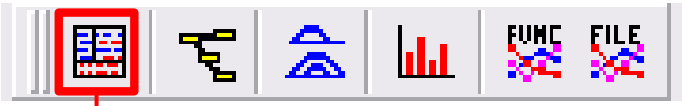
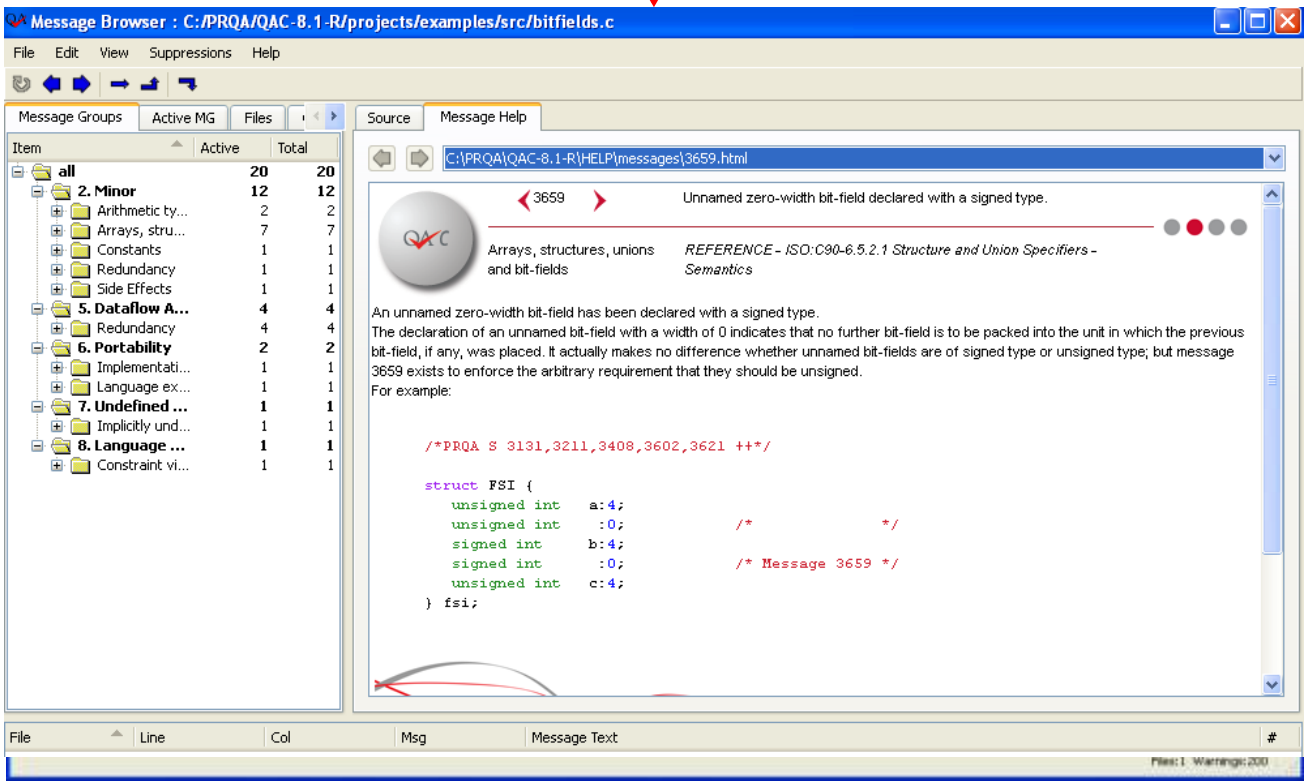
- 规则检查
  - 代码中违反规则的警告和错误





QAC功能介绍(4/8)

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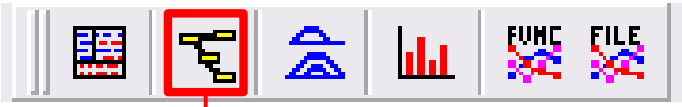
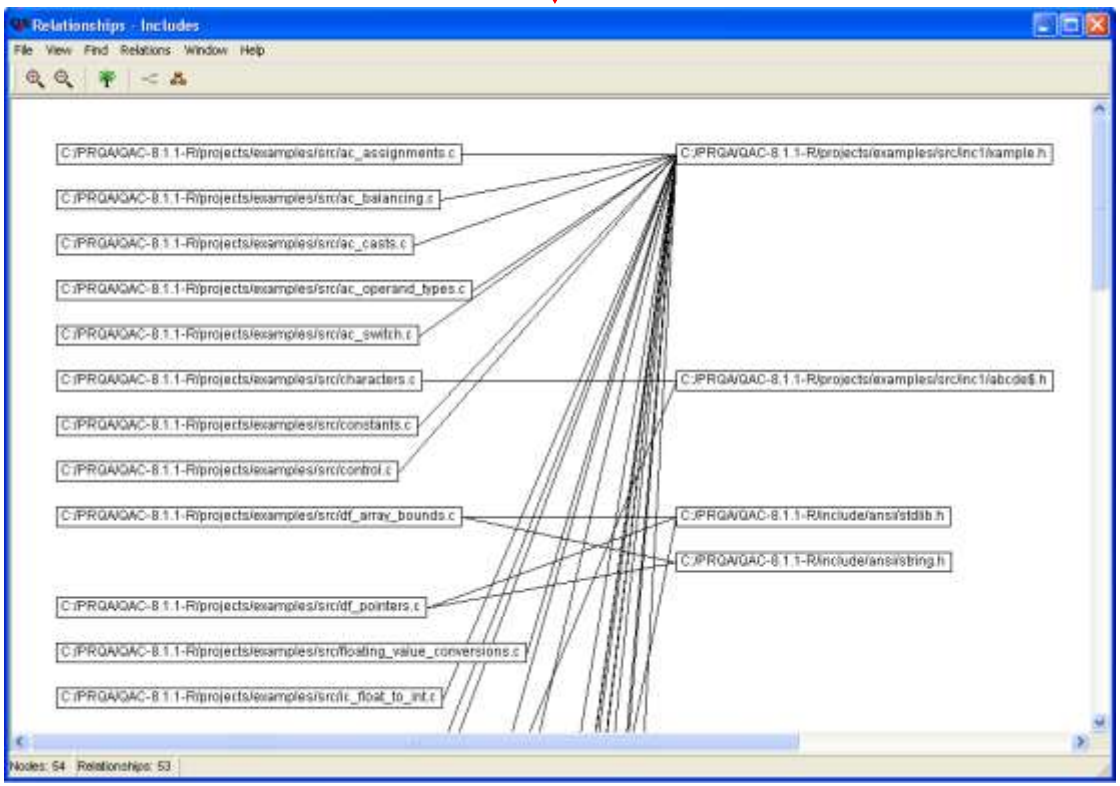
- 文件/函数结构分析
  - 循环引用
  - 影响分析





QAC功能介绍(5/8)

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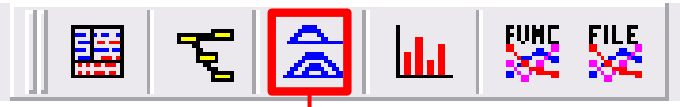
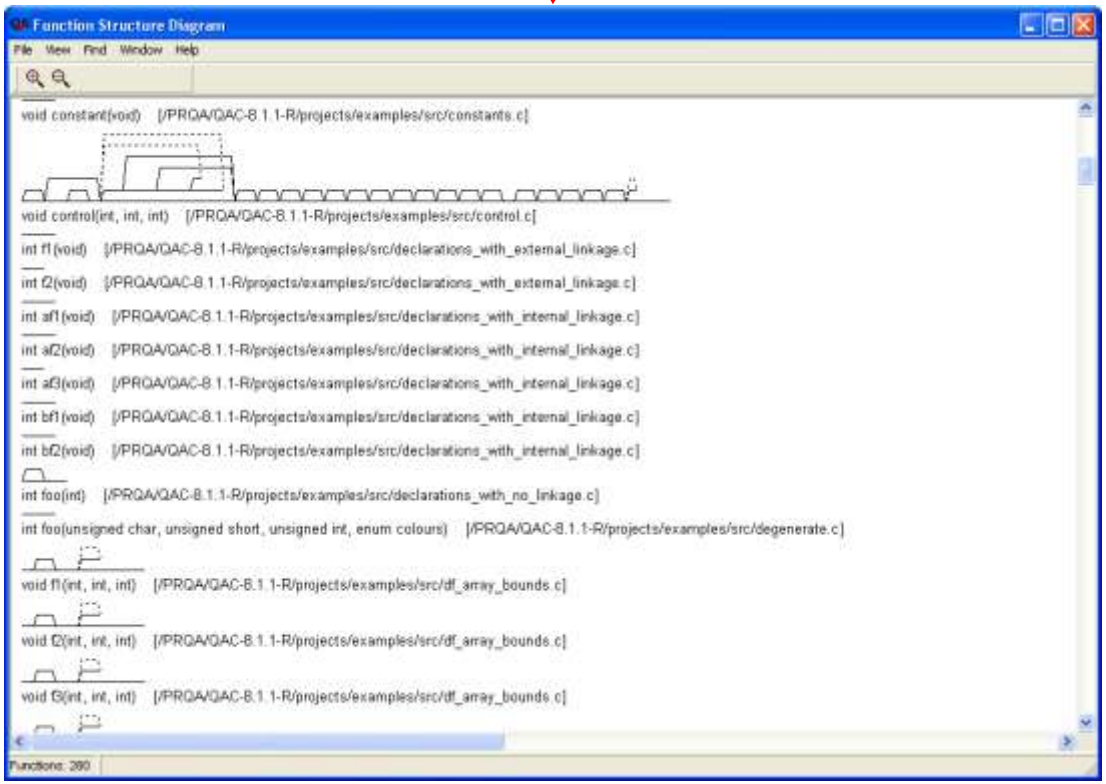
- 代码控制流分析
  - 程序复杂度
  - 代码相似度
  - 死代码
  - 交叉点





QAC功能介绍(6/8)

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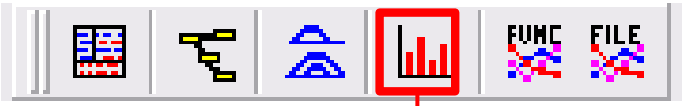
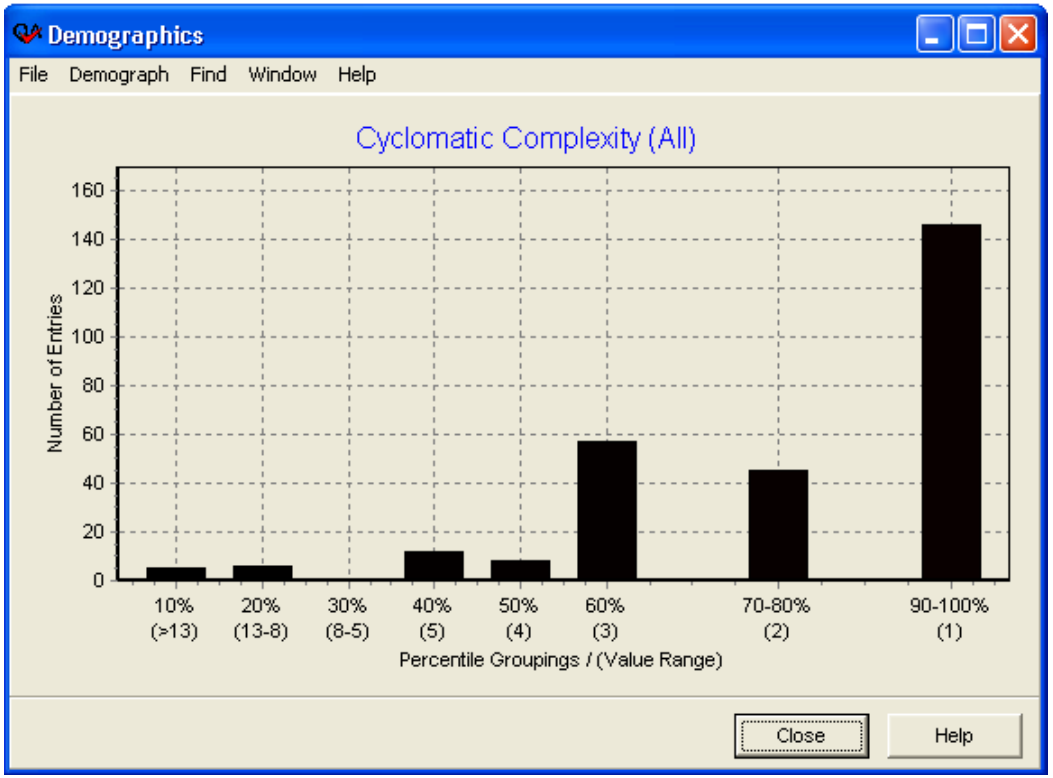
- 度量统计分析
  - 质量状态分布
  - 项目质量分析





QAC功能介绍(7/8)

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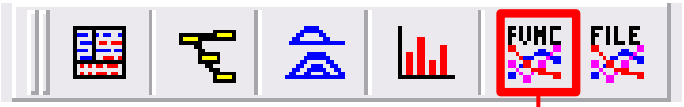
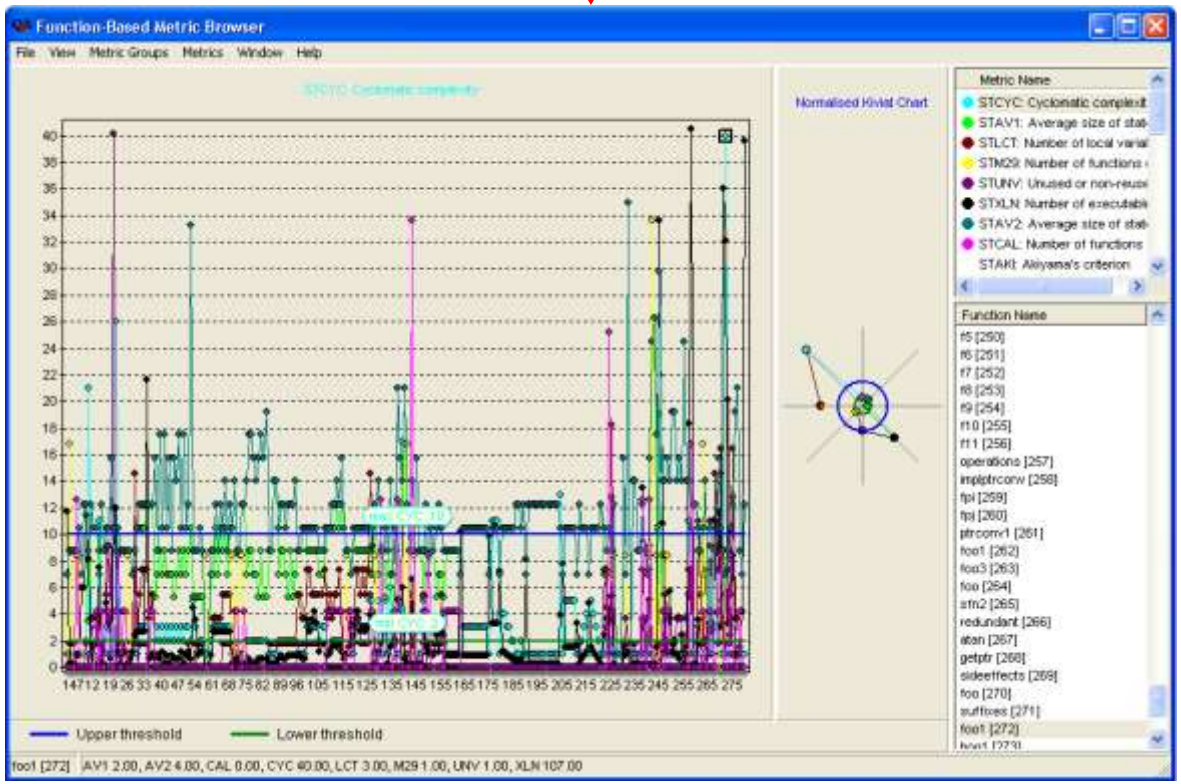
- 函数度量
  - 函数质量定量度量
  - 模块改进重点





QAC功能介绍(8/8)

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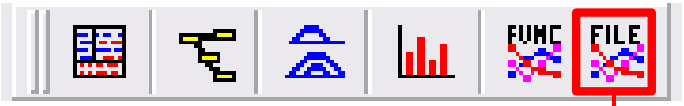
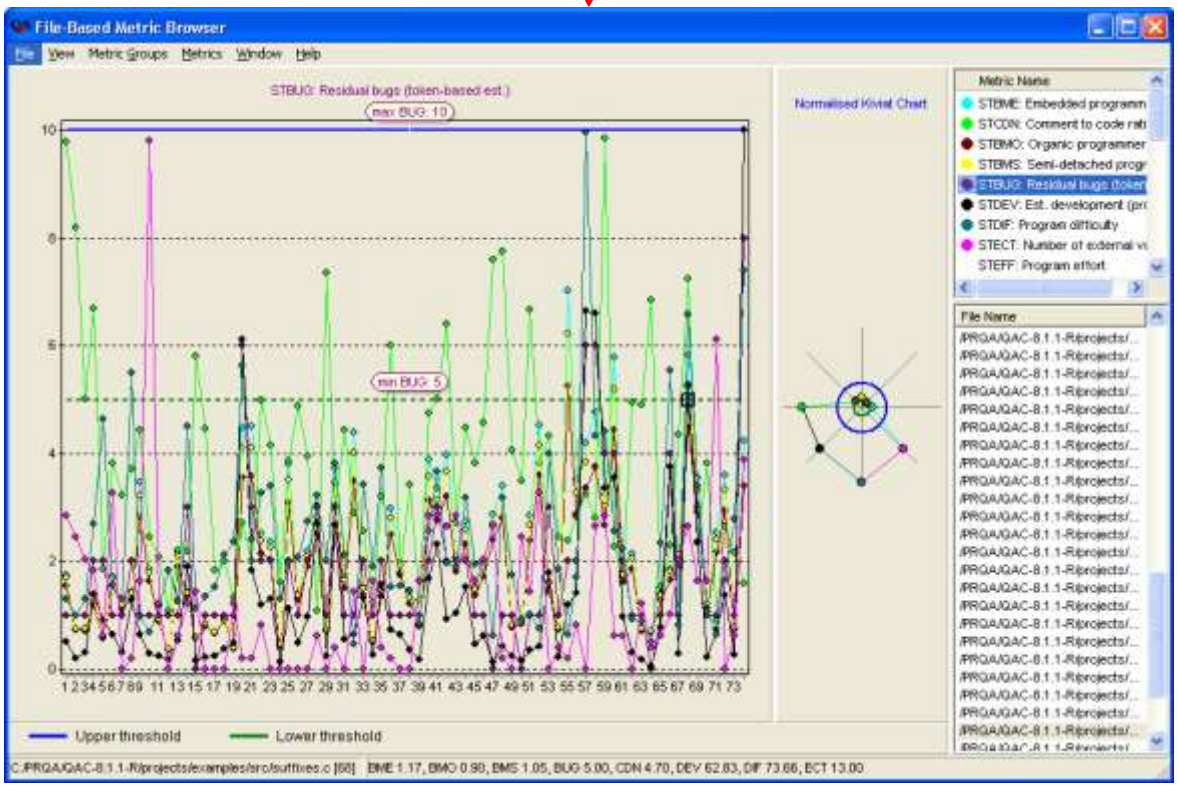
- 文件度量
  - 文件质量定量度量
  - 能力改进重点





福特公司的供应链案例

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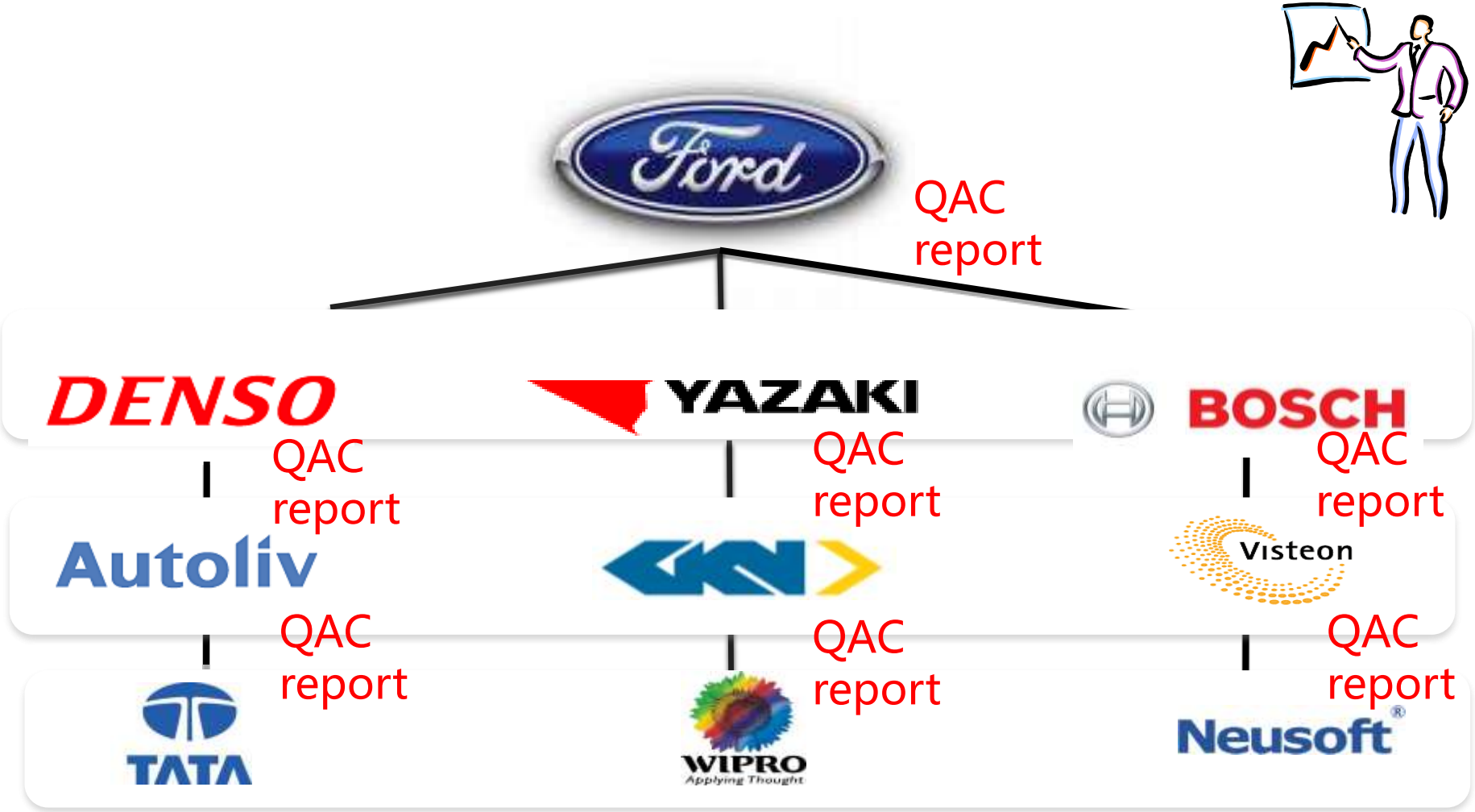

QAC应用方式

HYUNDAI
Drive your way™

QAC Report

Tier 1

MANDO
KEFICO
SL Corporation
S&T 대우
HYUNDAI MOBIS
DNPE 덴소풍성전자(주)

QAC Report

Tier 2

TeleChips
AutoEverSystems
Jatco
JATCO Korea Engineering Corp.
YURA
VEHICLE SYSTEM
Tyco Electronics
DAESUNG
eSysDTS
Kamtec

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Tessy

—嵌入式软件单元/集成/组件测试工具

Tessy应用

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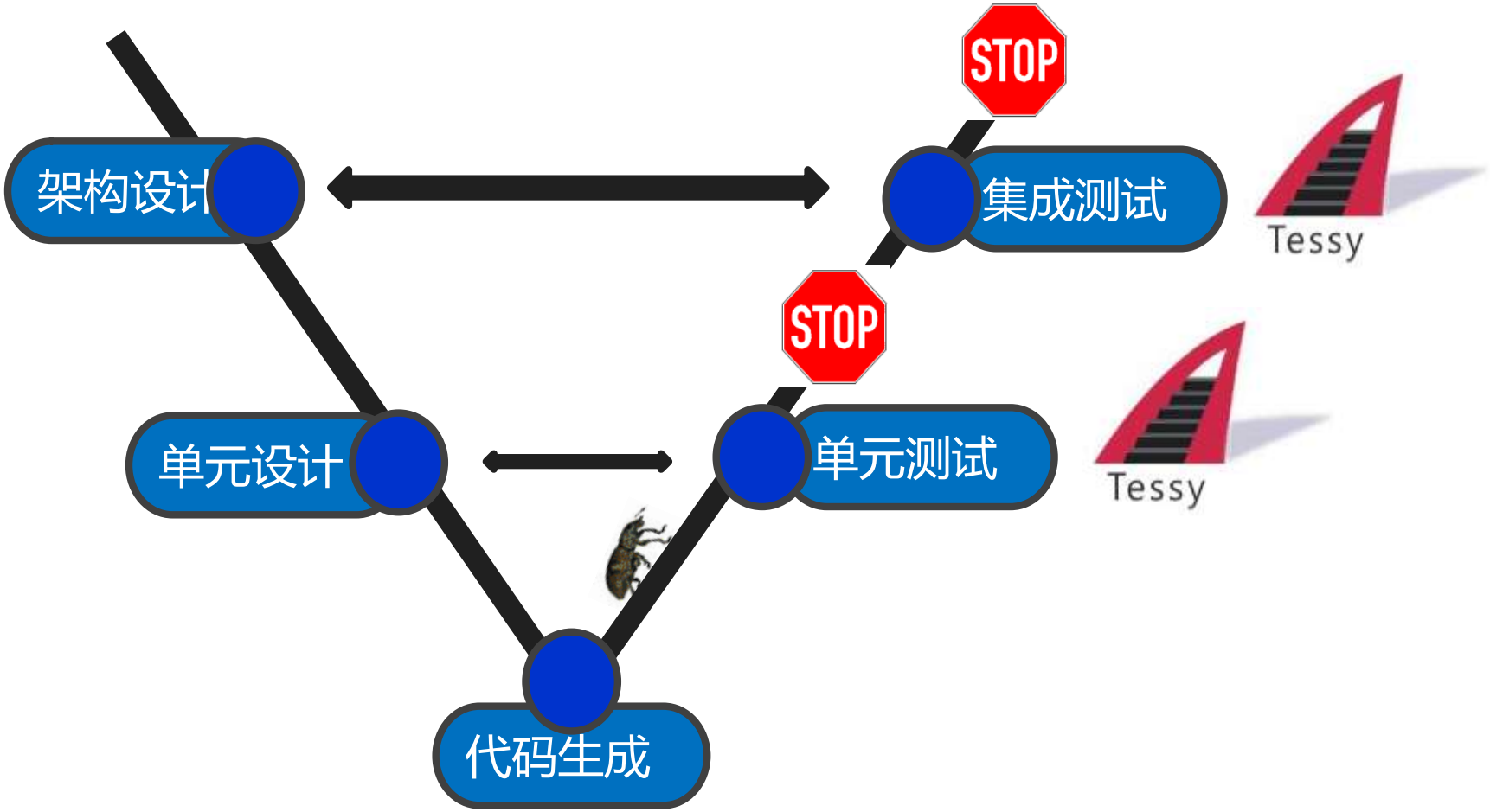

软件测试过程

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- 资格认证
  - IEC 61508 所有SILs
  - ISO 26262 所有SILs
  - DO178B 所有levels
  - Tessy也符合其他标准要求：
    如 DIN EN50128，IEC 62304

CERTIFICATE

ISO/FDIS 26262-6:2010(E)

Table 12 — Structural coverage metrics at the software unit level

Methods		ASIL			
		A	B	C	D
1a	Statement coverage	++	++	+	+
1b	Branch coverage	+	++	++	++
1c	MC/DC (Modified Condition/Decision Coverage)	+	+	+	++

NOTE 1 The structural coverage can be determined by the use of appropriate software tools.

NOTE 2 In the case of model-based development, the analysis of structural coverage can be performed at the model level using analogous structural coverage metrics for models.

NOTE 3 If instrumented code is used to determine the degree of coverage, it can be necessary to show that the instrumentation has no effect on the test results. This can be done by repeating the tests with non-instrumented code.

9.4.6 The test environment for software unit testing shall correspond as closely as possible to the target environment. If the software unit testing is not carried out in the target environment, the differences in the source and object code, and the differences between the test environment and the target environment, shall be analysed in order to specify additional tests in the target environment during the subsequent test phases.

Tessy功能介绍(1/10)

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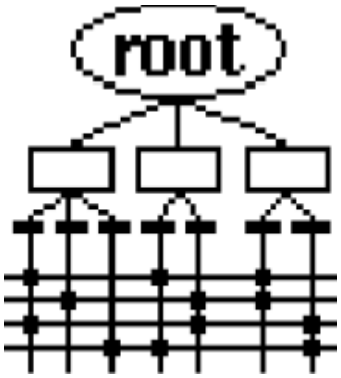
- 测试用例
  - 根据分类树方法进行设定（集成CTE）
  - 将Excel表格形式测试用例导入
  - 手工添加



Test Data of 'selectionsort'

Search for interface elements

	1.1	2.1	3.1
Inputs			
Globals			
Parameter			
long * array	target_array	target_array	target_array
long size	4	4	4
Dynamics			
long target_array[4]			
long target_array[0]	43	43	43
long target_array[1]	61	61	61
long target_array[2]	86	86	86
long target_array[3]	12	11	12
Outputs			
Globals			
Parameter			
Return			
long	3	3	3
Dynamics			
long target_array[4]			
long target_array[0]	12	12	12
long target_array[1]	43	43	43
long target_array[2]	61	61	61
long target_array[3]	86	86	86

Tessy功能介绍(2/10)

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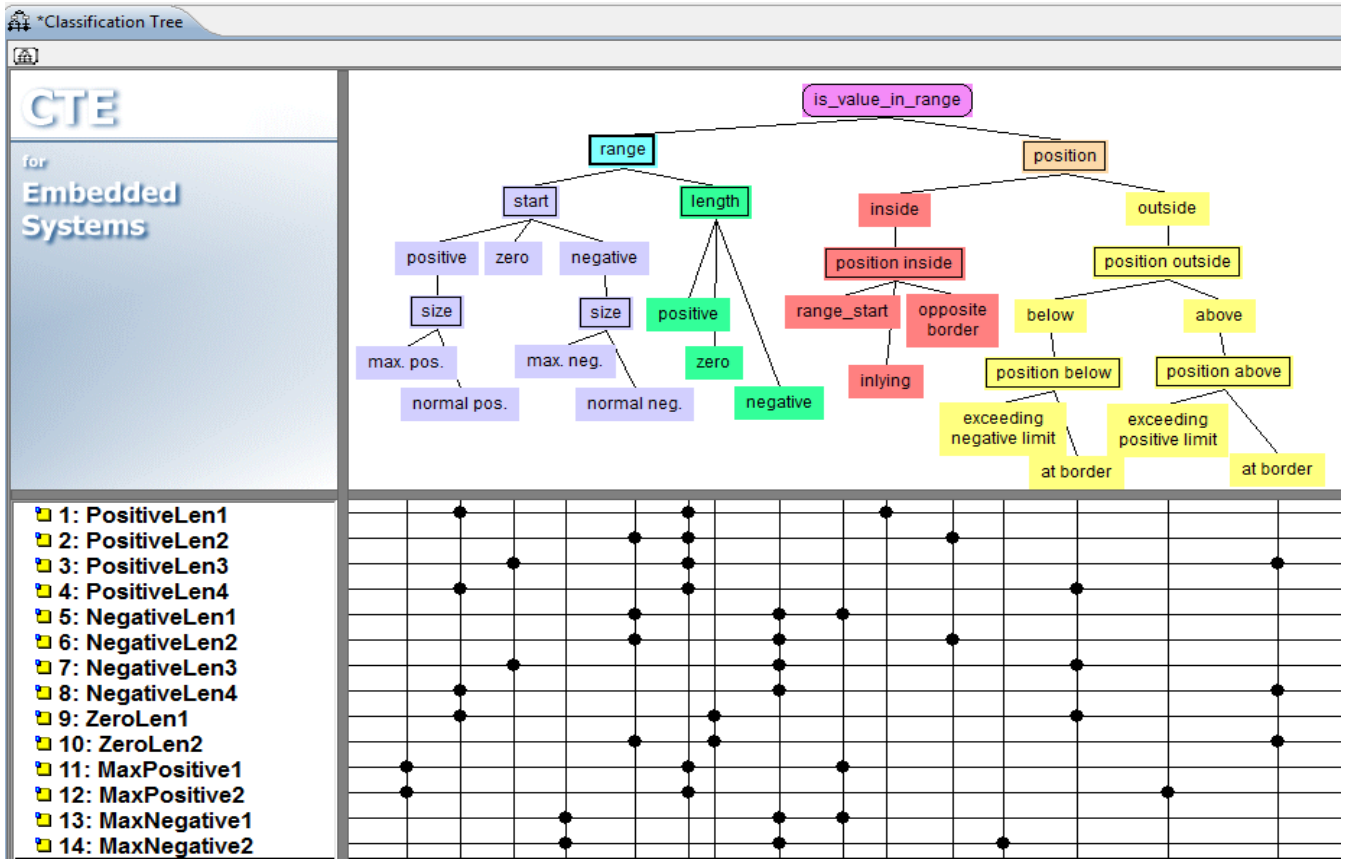
- 分类树Classification Tree Editor (CTE)
  - 可通过图形化辅助用户生成冗余度低且错误敏感度高的测试用例



Tessy功能介绍(3/10)

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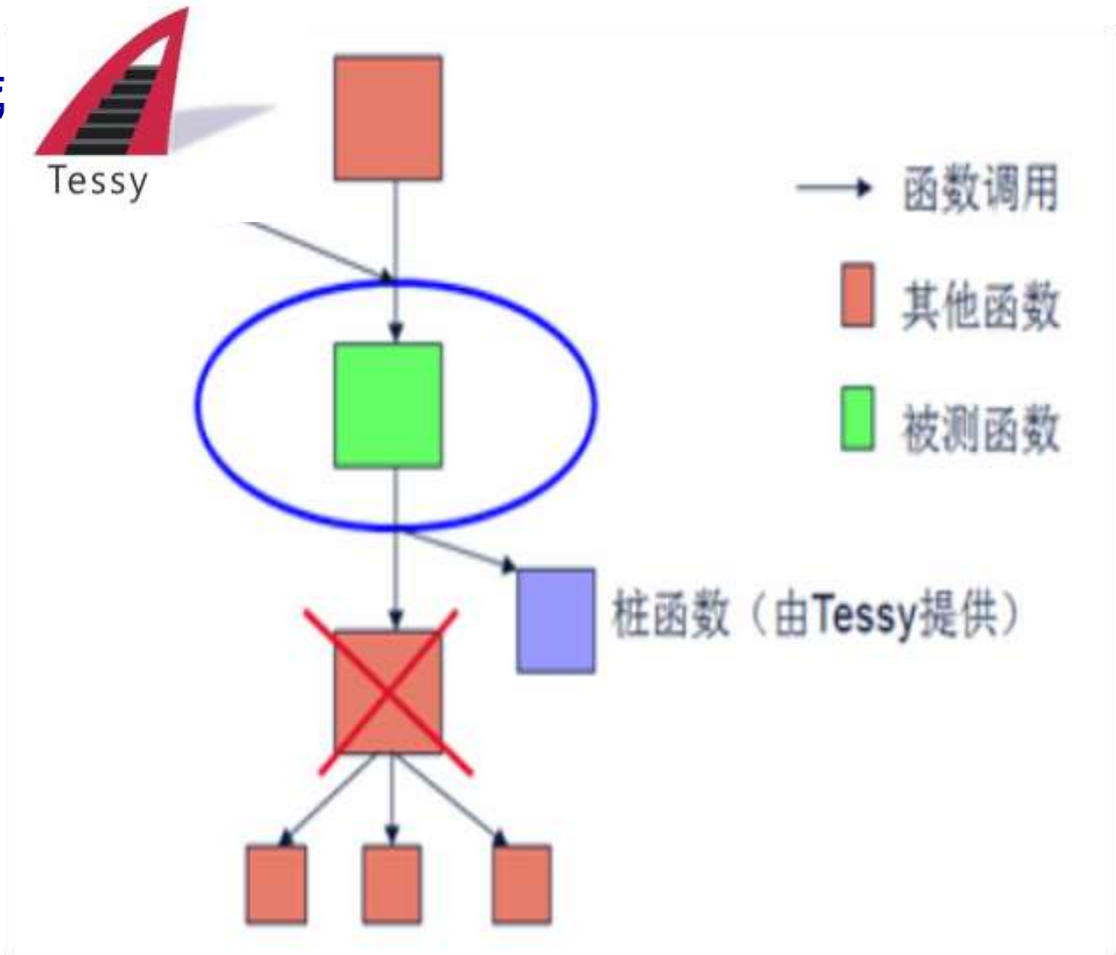
- 自动生成测试环境
  - 自动打桩
  - 自动生成驱动程序



Tessy功能介绍(4/10)

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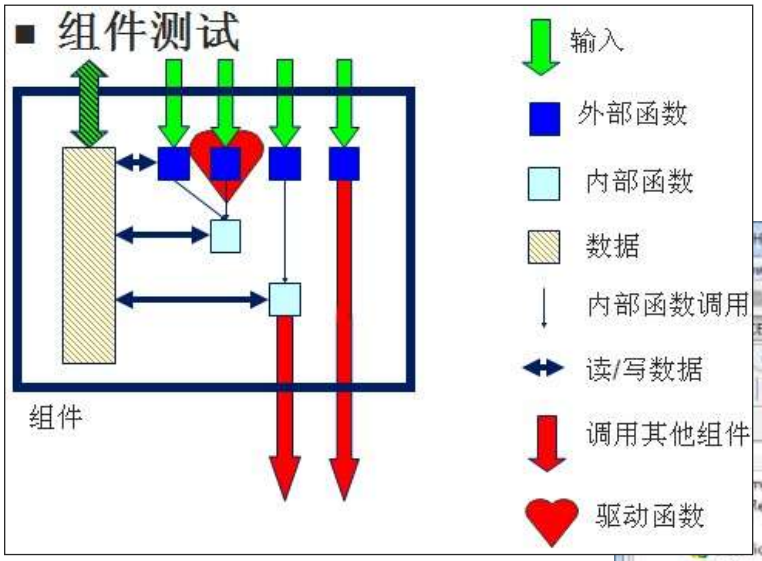
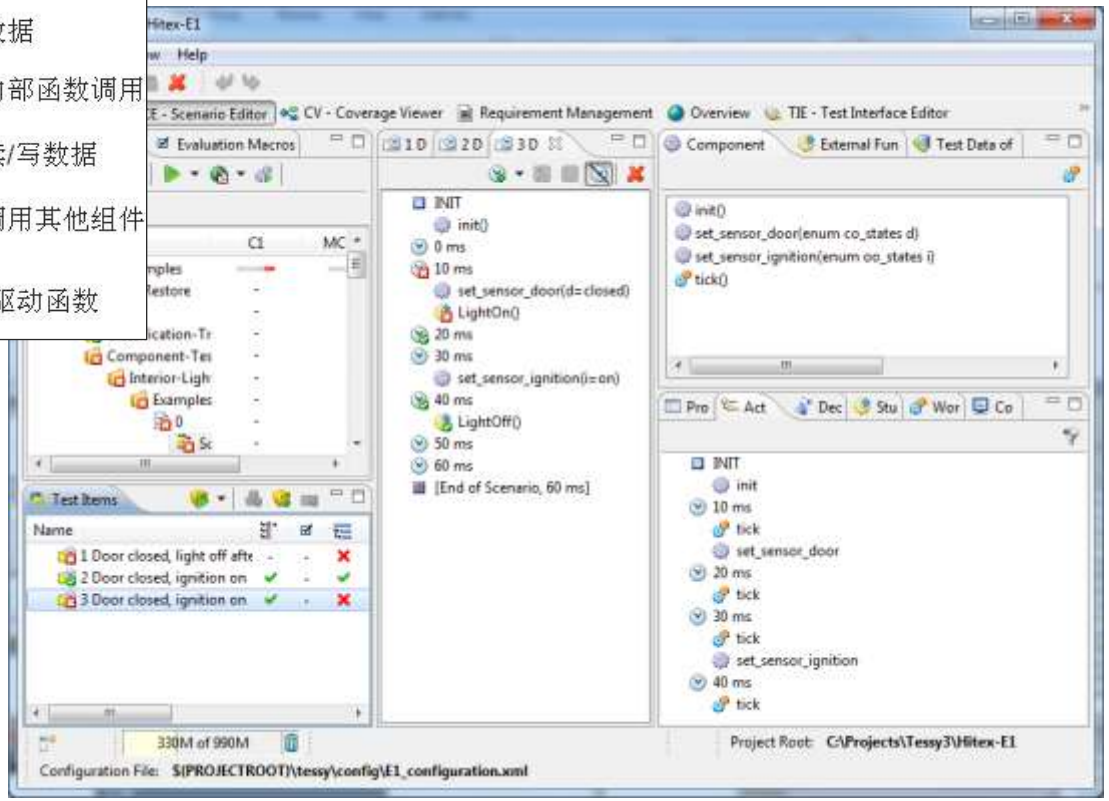
- 通过分析代码确定函数及他们之间的接口



Scenario Editor场景编辑器



Tessy功能介绍(5/10)

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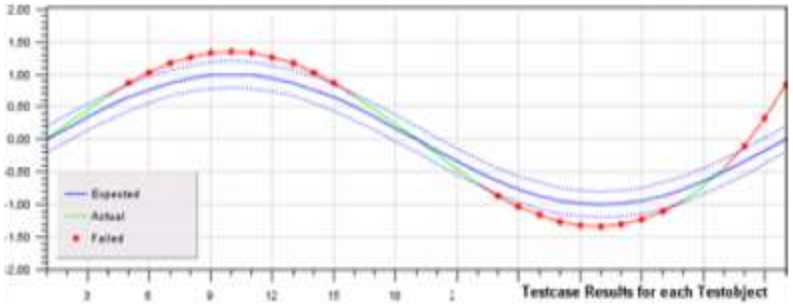
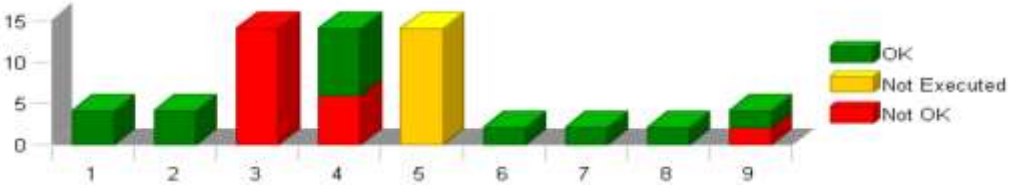
- 测试结果显示
  - 管理测试数据并将测试结果文档，Tessy可以生成多种格式的报告，包括XML (对于机器) ，PDF (对测试人员) 。



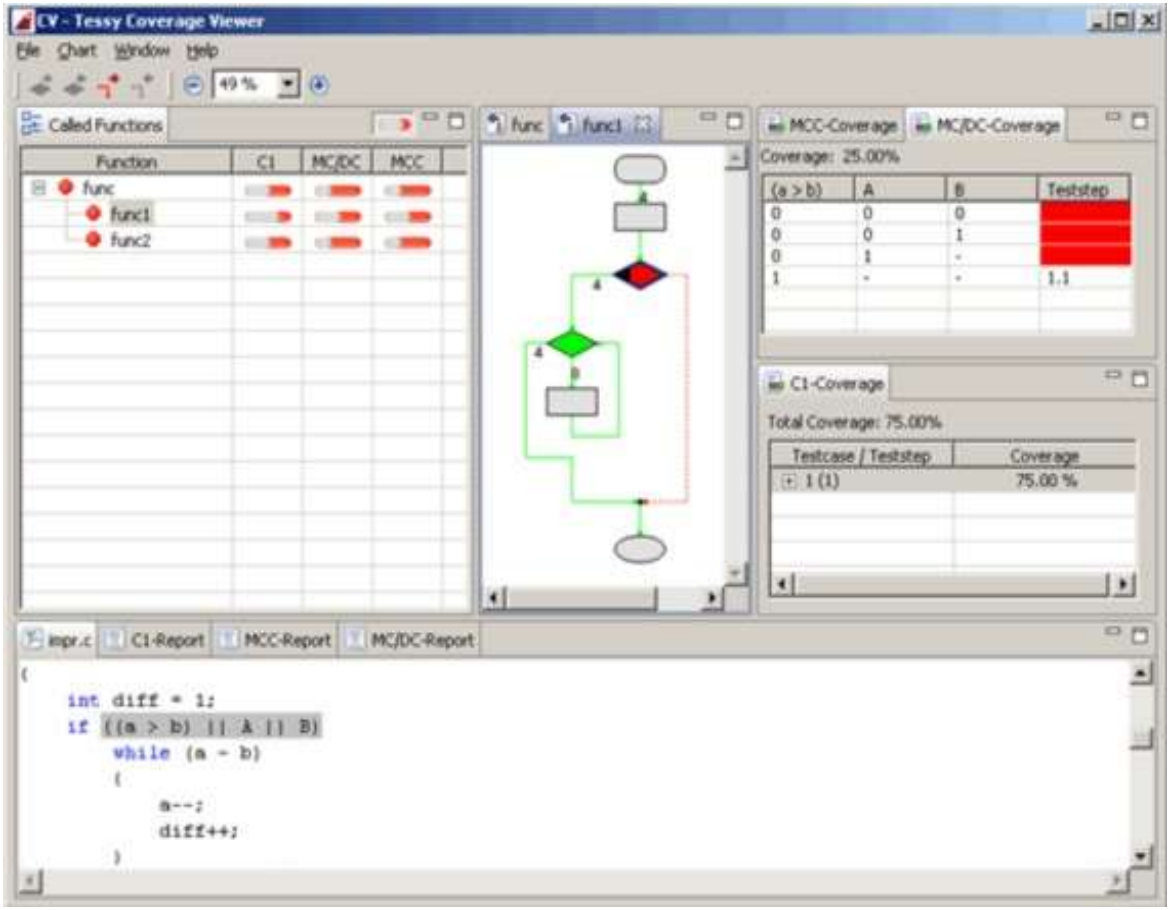


Test Step 2.1			
Name	**Input Value**		
array	target_array		
size	4		
target_array[0]	43		
target_array[1]	61		
target_array[2]	86		
target_array[3]	11		
Name	**Actual Value**	**Expected Value**	**Result**
selectionsort()	3	3	✔
target_array[0]	11	12	✖
target_array[1]	43	43	✔
target_array[2]	61	61	✔
target_array[3]	86	86	✔

No.	Name	Test Cases	Result
	Hitex-E1	22 of 60 failed	
	Hitex-Examples	22 of 60 failed	
	Batch+Restore	8 of 8 passed	✔
	Categorize	4 of 4 passed	✔
1	categorize	4 of 4 passed	✔
	Triangle	4 of 4 passed	✔
2	is_triangle	4 of 4 passed	✔
	Is-value-in-range	20 of 42 failed	
	GNU_0_CTEa	14 of 14 failed	
3	is_value_in_range	14 of 14 failed	
	GNU_0_CTEb	6 of 14 failed	
4	is_value_in_range	6 of 14 failed	
	GNU_ok_CTEb	-	
5	is_value_in_range	-	
	Stubs	2 of 10 failed	
	Different_Stubs	6 of 6 passed	✔
6	f1	2 of 2 passed	✔

Tessy功能介绍(6/10)

- 代码覆盖率
  - 分支覆盖
  - MC/DC 覆盖
  - MCC



Tessy功能介绍(7/10)

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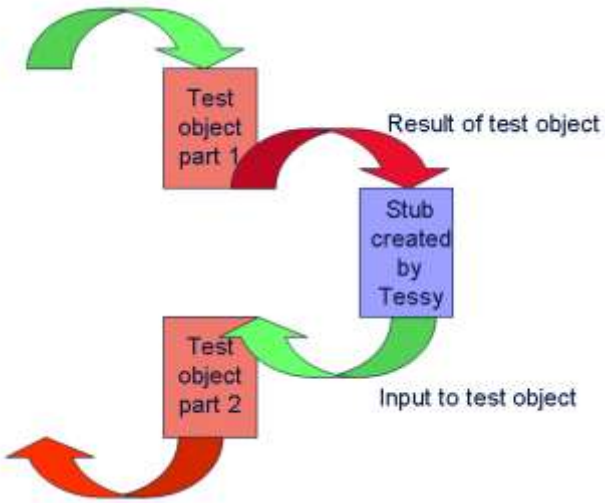
- 测试的执行和结果的评估
  - 全部自动化



- 回归测试
  - 重用测试用例和测试数据，
  - Tessy可以完全自动化地执行不需要用户介入的回归测试；无需用户交互

Tessy功能介绍(8/10)

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- Tessy可以和Hitops等多种调试器紧密结合

HiTOPS (Tessy-HISIM-ARM7.htp / HiSIM-ARM) - [ts_src01.c]

File Edit View Project Debug RTOS Analyze System Window Help

Workspace - ModuleVi...
- ts_is_value_in_range_s
  - startup_arm
  - ts_is_value_in_range_s
  - ts_is_value_in_range_usr
  - ts_src01
    - is_value_in_range
      - r1
      - v1
  - tscoml
  - tslows_hitop
  - tstcomm
  - Globals

ModuleView FileView

Disassembly | tslows_hitop | startup_arm | startup_arm | ts_src01

```
// e.g. r1.start = 5, r1.len = 2
// ==> v1 == 4 ---> no
//     v1 == 5 ---> yes
//     v1 == 6 ---> yes
//     v1 == 7 ---> no
// However, the implementation is intentionally
// erroneous: v1 == 7 results "yes" instead of "no"!
//

result is value in range (struct range r1, int v1)

    if (v1 < r1.range_start)
        return no;

    if (v1 > (r1.range_start + r1.range_len))
        return no;

    return yes;
```

Register

r0	00000005	N	1
r1	00000002	Z	0
r2	00000005	C	0
r3	00000006	V	0
r4	00000000	I	0
r5	00000000	F	1
r6	00000000	T	0
r7	00000000	s_N	0
r8	00000000	s_Z	0
r9	00000000	s_C	0
r10	2000FA78	s_V	0
r11	2000FE54	s_I	0
r12	2000FE58	s_F	0
r13	2000FF38	s_T	0

Memory - Mem0

Address	Data	ASCII
0x00000000	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....
0x00000010	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....
0x00000020	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....
0x00000030	00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	.....

Watch - Locals

Variables	Value		Type
r1	{5,2}		struct range
.range_start	5	0x00000005	int
.range_len	2	0x00000002	int
v1	6	0x00000006	int

Locals | Watch1 | Watch2

Callstack
- is_value_in_range() #30
- tessy_execute_task() #174

Output

```
%ice_halted
DUMP ts_sync_state
```

HiSCRIPT Log | Messages | Find in Files | Build

Ready Break (1): Line step Debug Ln 30, Col 1 CAP NUM SCRL Halted

Tessy功能介绍(9/10)

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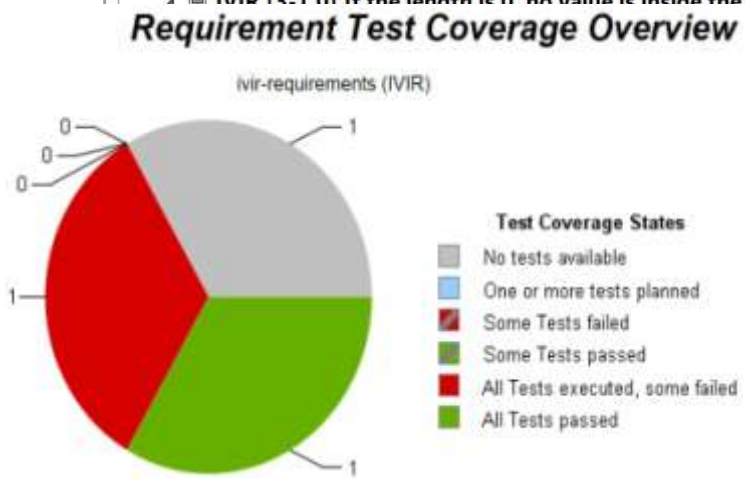
- 需求可溯性

Planning | Execution

type filter text

All				2
IVIR [1-1.0] Is a value in a given range? The range is given by a start value and a range.				1
is_value_in_range				1
is_value_in_range				1
1				1
2				0
IVIR [2-1.0] The end of the range shall not be inside the range.				1
is_value_in_range				1
is_value_in_range				1
1				
2				
IVIR [3-1.0] If the length is 0, no value is inside the				



Test Means | IVIR_VxV 1.0 | VxV Matrix | Link Matrix | Suspicious Elements | Differences - [2 - 1.0]

```
1 Requirement Properties
2 ----------------------------
3
4 RQMT-ID:   2
5 Version:                1.0
6 Priority:     UNDEFINED
7
8 Short Description:
9
10
11 Text:
12 The end of the range shall not be inside the range.
13
14 Linked Test Means:
15 Unit Test
16
17
```

```
1 Requirement Properties
2 ----------------------------
3
4 RQMT-ID:   2
5 Version:                2.0
6 Priority:     UNDEFINED
7
8 Short Description:
9
10
11 Text:
12 The end of the range shall be inside the range.
13
14 Linked Test Means:
15 Unit Test
16
17
```

CHANGE: 1 | REMOVE: 1 | ADD: 0 | TOTAL: 2

Tessy功能介绍(10/10)

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- 支持 ASAP2：自动化和测量系统标准化协会制定ASAM MCD-2MC标准 A2L文件

ABS
EPS
ECU
发动机
变速箱

Properties

General | ASAP

Description

Recommended speed

Info

Unit:	mph
Format:	%7.3
Min:	0.000
Max:	800.000

Interface of 'CalcRecommendedSpeed'

Search for interface elements

	Passing
External Functions	
Local Functions	
External Variables	
Global Variables	
unsigned char air_temp [°C]	IN
unsigned char rec_speed [mph]	OUT
Parameter	
Return	

Test Data of 'CalcRecommendedSpeed'

Search for interface elements

	1.1	2.1
Inputs		
Globals		
unsigned char air_temp [°C]	23.00	*min*
Parameter		
Dynamics		
Outputs		
Globals		
unsigned char rec_speed [mph]	124.000	*max*
Parameter		
Return		
Dynamics		

Test Case 1

Comment: Range for air_temp is from -40 °C (= 0) to 50 °C (= 90).
Range for rec_speed is from 0 mph (= 0) to 800 mph (=200).
23° C = 63 (test object internal representation, decimal).
For 63 the test object returns 31 (decimal) for the recommeded speed.
31 = 124 mph

Test Step 1.1 (Repeat Count = 1)

Name	Input Value
air_temp	23.00

Name	Actual Value	Expected Value	Result
rec_speed	124.000	124.000	✓

集成硬件

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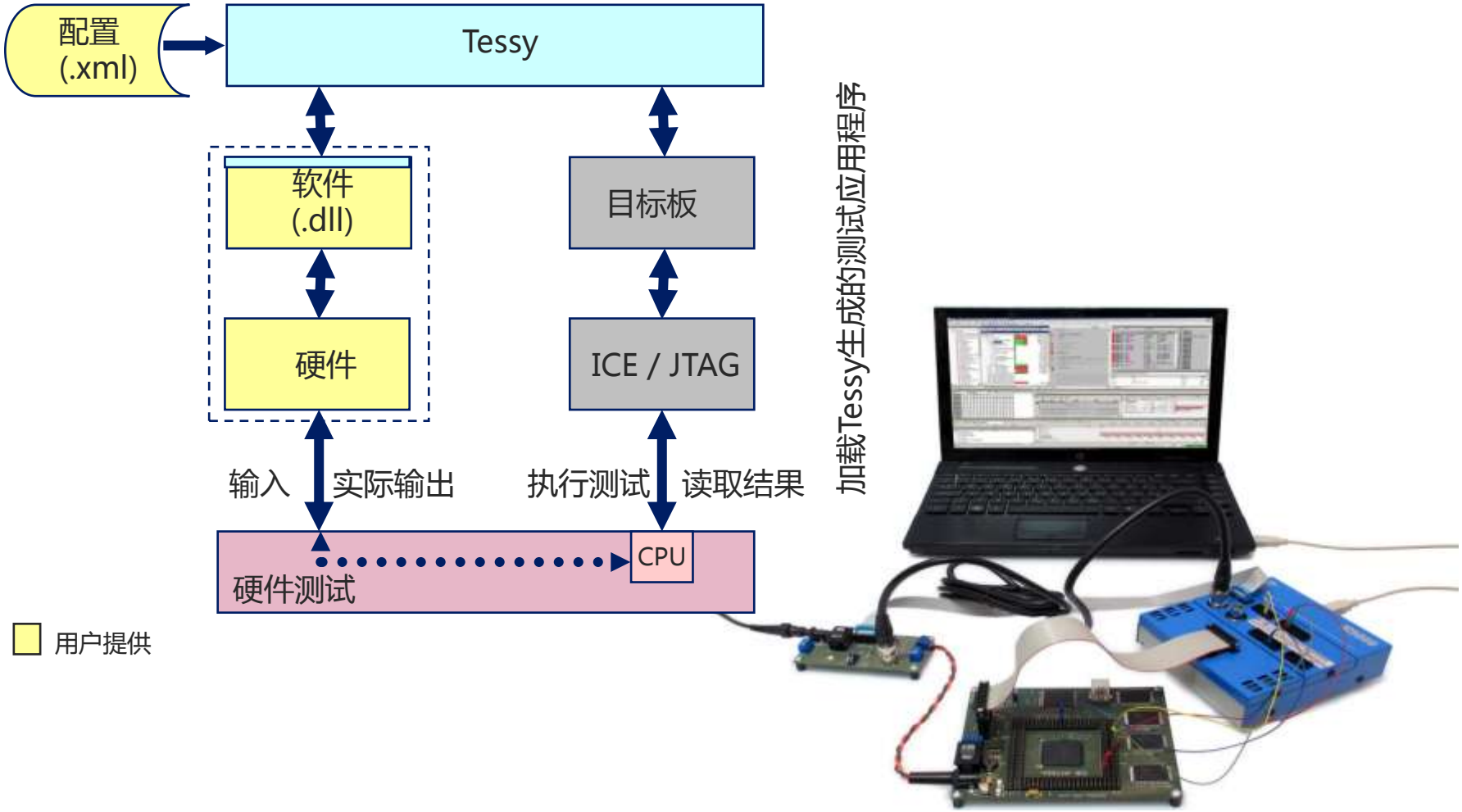
- Tessy 与目标板的集成方式



支持集成

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- Tessy支持多种集成
  - 微控制器 (microcontroller)
  - 交叉编译器 (cross-compiler)
  - 仿真机(simulators)
    - OCDS/JTAG/BDM

- Tessy安装环境
  - Windows 2000 / XP / Vista/7

Compilers and Debuggers/Emulators supported by Tessy

Table A :: 1-3

supported targets since TESSY v3.0.18

Compiler \ Debugger	CCS (Texas Instruments)	CDT Debugger	Codewarrior (Freescale)	Crossview (Tasking)	C-Spy (IAR)	Fastview (PLS)	HEW (Renesas)	HighTec GNU (HighTec)*	HITOP (Hitex)	MULTI 2000 (Green Hills)	MPLAB (MICROCHIP)*	Nios II GNU Debugger *	Noral Flex (Noral)	Phyton PICE-MC	SingleStep (Windriver)	SM78K0(S)/ID78K0(S)(NEC)	Softune (Fujitsu)	STVD (ST Microelectr.)	TRACE32 (Lauterbach)	UDE (PLS)	Visual DSP (Analog Devices)	Wind River Workbench	µVision (Keil)	winIDEA (ISYSTEM)	ZAP (Cosmic)
ALTERA																									
NIOS II												✓							✓						
Analog Devices																									
Blackfin																					✓				
ARM																									
ADS Arm									✓										✓						
ARM RVDS									✓										✓	✓			✓		
Cosmic																									
HC11									✓										✓					✓	
HCS12									✓				✓						✓					✓	✓
HCS08									✓										✓					✓	
S12X																			✓					✓	✓
ST7									✓									✓						✓	
STM8																		✓							
DiabData																									
PPC5xx (s. WindRiver)									✓						✓				✓					✓	
Freescale (Metrowerks)																									
Coldfire V1			✓																						
DSP568E			✓																						
HCS12			✓						✓										✓					✓	
HCS08			✓						✓										✓					✓	
MPC5xxx																			✓					✓	
S12X			✓																✓					✓	
ST7									✓									✓							
Fujitsu																									
FFMC16																	✓								
FFMC32																	✓								
GNU																									
Arm / Arm Cortex									✓										✓						
GCC		✓																							
PPC																			✓						
Green Hills																									
Arm (++)										✓															
MPC										✓									✓						
V850										✓									✓					✓	
x86										✓															
HighTec																									
PPC																			✓						
Tricore								✓											✓	✓					

小结

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Tessy

- CTE(分类树方法)
- 多覆盖度测试
- 支持多种报告格式
- 支持与多种编译器集成
- 回归测试