Integrated diagnostics

- **Keiner (1990):**
  "... a structured process which maximizes the effectiveness of diagnostics by integrating the individual diagnostic elements of
  - **testability,**
  - **automatic testing,**
  - **manual testing,**
  - **training,**
  - **maintenance aiding and**
  - **technical information."**
- **Goal: Optimization of field-maintenance**
  - **resources**
  - **MT to fault isolation**
  - **MTTR**
  - **spare parts**
  - **training**

Principal components:

- **Design for testability evaluation tools**
  - Diagnostic capabilities of the test set
    - generic -
    - specific (system or mission level) testability allocation
  - result
    - design new tests
    - eliminate old tests
    - redesign the system
  - diagnostic strategies
- **Structured approach**
  - covering hierarchical details
    - applicable at different maintenance levels
    - different technologies and interfaces
  - on-line or off-line testing
  - mechanism for efficient analysis
  - information fusion

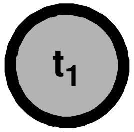
Testability

- "... a design characteristics which allows
  the status (operable, inoperable, or degraded) of an item to be determined
  and the isolation of faults within the item to be performed
  in a timely and efficient manner."
  - inherent
    - design characteristic
    - potential ability to observe system behaviour under test stimuli
    - location, accessibility and sophistication of tests
  - achieved
    - maintenance characteristic
    - actual ability to observe system behaviour under test stimuli
    - result of the diagnostic process
    - realized false alarms, ambiguities, correct and incorrect diagnoses
- Test (information fusion)
  "a signal, indication or other observable event that may a normal output of a system
  or be caused to happen."
- Restricted to: permanent faults and binary pass/fail tests
- Diagnostic goals:
  - detection
  - localization
  - isolation

Model of the diagnostic system

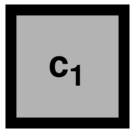
- **Primitive elements**

  - **Tests**



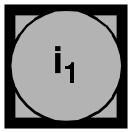
    - **Any information source**
    - **Binary (Go/NoGo)**
    - **Fault isolation conclusions**

    Any element that we can isolate (e.g. failure mode of a component)



  - **special elements**

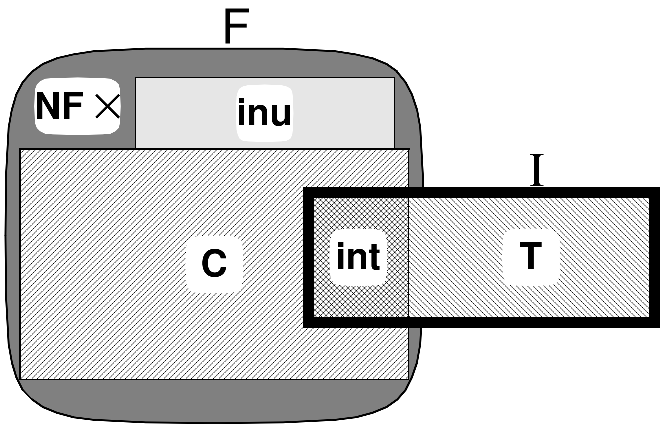
    - ***testable input*: input +test**



    - ***untestable input***
    - ***RTOK* (no fault, for retest okay)**

Diagnostic resolution

- **Depends on the repair level**
  - **Failure mode**
  - **Line-replaceable unit (LRU)**
  - **Shop-replaceable unit (SRU)**
  - **Components at the depot level**



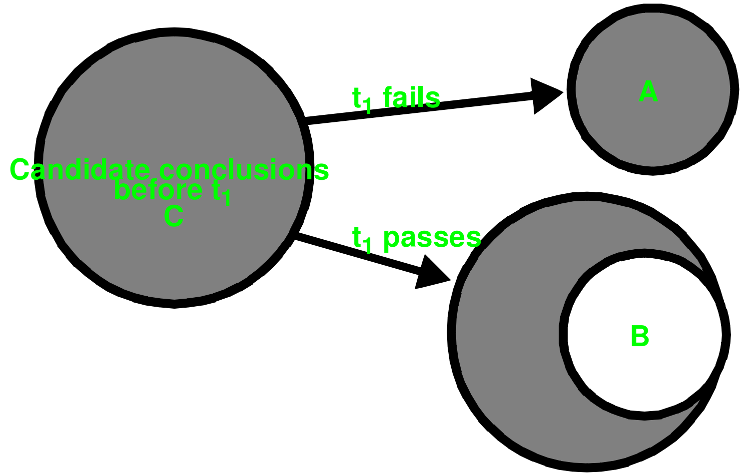
Dependency (implication) relationships

- Logical relationships
  - inferences drawn from a test failing
    - conclusion list: explain the current test failure
    - test list: should they fail, would cause the current test to fail
  - inferences drawn from a test passing
- Representation as a directed graph
  - Vertices:
    - Tests
    - Conclusions
  - Edges
    - Dependencies
    - $(t_i,c_j) \in E$: If t_i fails
- Order
  - First order
    - direct implication $\Leftrightarrow$ edge
  - Higher order
    - transitive implication $\Leftrightarrow$ directed path

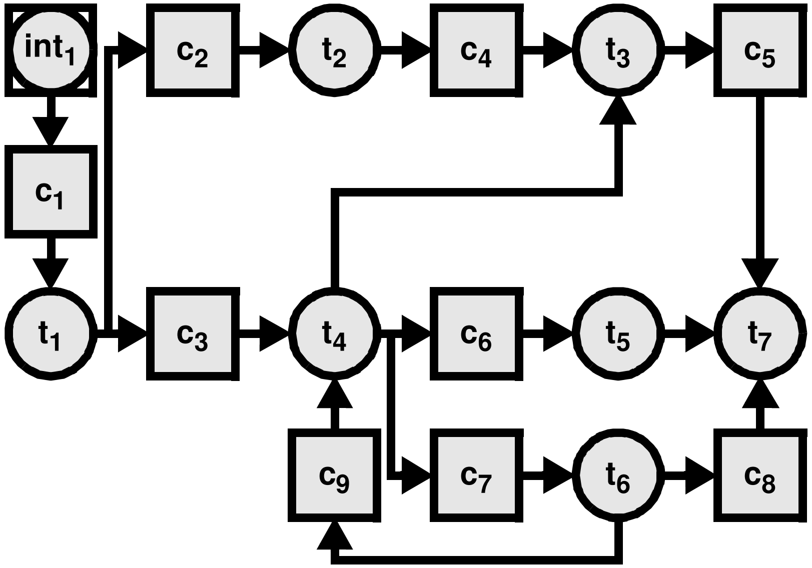
Test variants

- **Implied sets by t_i:**
  - **Pass (t_i): set of excluded conclusions and test that should pass**
  - **Fail (t_i): set of candidate conclusions and test that should fail**
- **Test fails: some candidate conclusions (A)**
- **Test passes: some candidates before test (B) rejected**

Type	Name	Condition
Symmetric		$A=B$
Asymmetric	Positive inference	$A=C$ $B=D^{-1}(t)$
	Negative inference	$B=\varnothing$ $A=D$
	Fully asymmetric	
	Cross-linked	$t_1=1 \rightarrow t_2=0$
		$t_1=0 \rightarrow t_2=1$
		$t_1 \rightarrow t_2=\bar{t}_1$

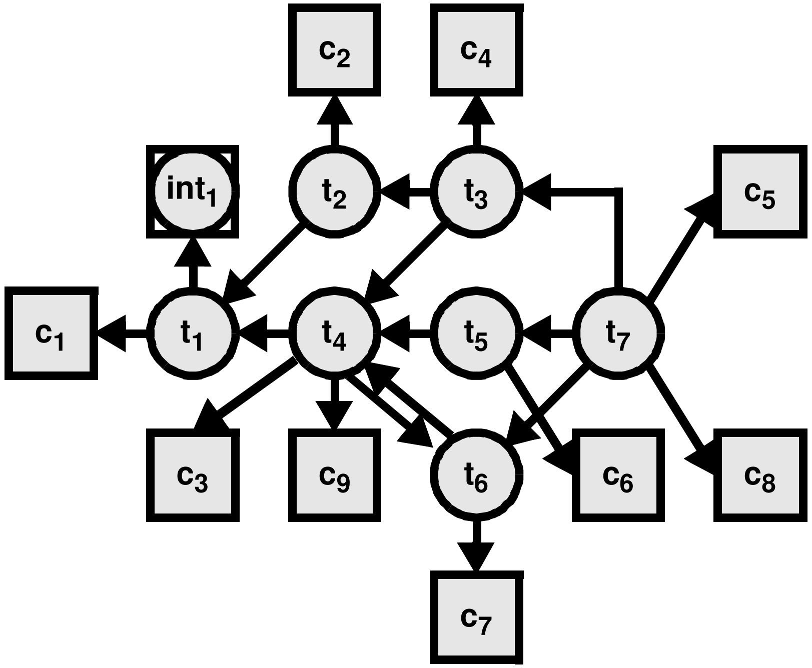


The model (symmetric tests)



	test-test dependency							
	int1	t1	t2	t3	t4	t5	t6	t7
int1		f	h	h	h	h	h	h
t1			f	h	f	h	h	h
t2				f				h
t3								f
t4				f	h	f	f	h
t5								f
t6				h	f	h	h	f
t7								h
conclusion-test dependency								
int1	f	h	h	h	h	h	h	h
c1		f	h	h	h	h	h	h
c2			f	h				h
c3				h	f	h	h	h
c4				f				h
c5								f
c6						f		h
c7				h	h	h	f	h
c8								f
c9				h	f	h	h	h
NF								

- **If t_1 fails, then t_2 will also fail and respectively If t_1 pass, then t_2 will also pass**



- **First order dependencies**
- **Dependency between**
  - **Test-test**
  - **Conclusion-test**

	First order test-test dependency																			
	t1	**t2**	**t3**	**t4**	**t5**	**t6**	**t7**	**t8**	**t9**	**t10**	**t11**	**t12**	**t13**	**t14**	**t15**	**t16**	**t17**	**t18**	**int1**	**int2**
t1				f																
t2			f																	
t3	f			f																
t4													f							
t5				f		f														
t6							f													
t7								f												
t8									f											
t9										f								f		
t10											f									
t11												f								
t12													f							
t13														f			f			
t14															f	f				
t15																f				
t16																				
t17																f				
t18												f								
int1	f	f																		
int2			f	f																

First order conclusion-test dependency

	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14	t15	t16	t17	t18	int1	int2
int1																			f	
int2																				f
c1	f																			
c2	f																			
c3		f																		
c4			f																	
c5					f															
c6	f				f					f										
c7						f														
c8							f													
c9								f												
c10									f											
c11										f										
c12										f										
c13																				
c14											f									
c15												f								
c16													f							
c17													f							
c18													f							
c19														f			f			
c20															f	f				
c21				f																
inu1														f	f	f				
inu2													f							
NF																				

Transitive Closure (implication chains)

	Test-test dependency																			
	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14	t15	t16	t17	t18	int1	int2
t1				f											h	h	h			
t2	h		f	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h		
t3	f		h	f	h	h	h	h	h	h	h	h	h	h	h	h	h	h		
t4													f	h	h	h	h			
t5				f		f	h	h	h	h	h	h	h	h	h	h	h	h		
t6						h	f	h	h	h	h	h	h	h	h	h	h	h		
t7						h	h	f	h	h	h	h	h	h	h	h	h	h		
t8						h	h	h	f	h	h	h	h	h	h	h	h	h		
t9						h	h	h	h	f	h	h	h	h	h	h	h	f		
t10											f	h	h	h	h	h	h			
t11												f	h	h	h	h	h			
t12													f	h	h	h	h			
t13														f	h	h	f			
t14															f	f				
t15																f				
t16																				
t17																f				
t18					h	h	h	h	h	h	h	f	h	h	h	h	h	h		
int1	f	f	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h		
int2	h		f	f	h	h	h	h	h	h	h	h	h	h	h	h	h	h		

Conclusion-test dependency

	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14	t15	t16	t17	t18	int1	in2
int1	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	f	
in2	h		h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h		f
c1	f			h									h	h	h	h	h			
c2	f			h									h	h	h	h	h			
c3	h	f	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h		
c4	h		f	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h		
c5				h	f	h	h	h	h	h	h	h	h	h	h	h	h	h		
c6	f			h	f	h	h	h	h	f	h	h	h	h	h	h	h	h		
c7						f	h	h	h	h	h	h	h	h	h	h	h	h		
c8						h	f	h	h	h	h	h	h	h	h	h	h	h		
c9						h	h	f	h	h	h	h	h	h	h	h	h	h		
c10						h	h	h	f	h	h	h	h	h	h	h	h	h		
c11										f	h	h	h	h	h	h	h			
c12										f	h	h	h	h	h	h	h			
c13																				
c14											f	h	h	h	h	h	h			
c15												f	h	h	h	h	h			
c16													f	h	h	h	h			
c17													f	h	h	h	h			
c18													f	h	h	h	h			
c19														f	h	h	f			
c20															f	f				
c21				f									h	h	h	h	h			
inu1														f	f	f	h			
inu2													f	h	h	h	h			
NF																				

Logic Closure

Test-test dependency

	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14	t15	t16	t17	t18	int1	int2
t1				f											h	h	h			
t2	h		f	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h		
t3	f		h	f	h	h	h	h	h	h	h	h	h	h	h	h	h	h		
t4													f	h	h	h	h			
t5				f		f	h	h	h	h	h	h	h	h	h	h	h	h		
t6						h	f	h	h	h	h	h	h	h	h	h	h	h		
t7						h	h	f	h	h	h	h	h	h	h	h	h	h		
t8						h	h	h	f	h	h	h	h	h	h	h	h	h		
t9						h	h	h	h	f	h	h	h	h	h	h	h	f		
t10											f	h	h	h	h	h	h			
t11												f	h	h	h	h	h			
t12													f	h	h	h	h			
t13														f	h	h	f			
t14															f	f	l			
t15																f				
t16															l					
t17														l		f				
t18					h	h	h	h	h	h	h	f	h	h	h	h	h	h		
int1	f	f	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h		
int2	h		f	f	h	h	h	h	h	h	h	h	h	h	h	h	h	h		

$C^{-1}(t_x) \supseteq C^{-1}(t_y) \Rightarrow t_x \leftarrow t_y$

Conclusion-test dependency

	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14	t15	t16	t17	t18	int1	int2
conclusion-test dependency																				
int1	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	f	
int2	h		h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h		f
c1	f			h									h	h	h	h	h			
c2	f			h									h	h	h	h	h			
c3	h	f	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h		
c4	h		f	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h		
c5				h	f	h	h	h	h	h	h	h	h	h	h	h	h	h		
c6	f			h	f	h	h	h	h	f	h	h	h	h	h	h	h	h		
c7						f	h	h	h	h	h	h	h	h	h	h	h	h		
c8						h	f	h	h	h	h	h	h	h	h	h	h	h		
c9						h	h	f	h	h	h	h	h	h	h	h	h	h		
c10						h	h	h	f	h	h	h	h	h	h	h	h	h		
c11										f	h	h	h	h	h	h	h			
c12										f	h	h	h	h	h	h	h			
c13																				
c14											f	h	h	h	h	h	h			
c15												f	h	h	h	h	h			
c16													f	h	h	h	h			
c17													f	h	h	h	h			
c18													f	h	h	h	h			
c19														f	h	h	f			
c20															f	f				
c21				f									h	h	h	h	h			
inu1														f	f	f	h			
inu2													f	h	h	h	h			
NF																				

Incremental Closure

Test-test dependency

	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14	t15	t16	t17	t18	int1	int2
t1				f											h	h	h			
t2	h		f	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h		
t3	f		h	f	h	h	h	h	h	h	h	h	h	h	h	h	h	h		
t4													f	h	h	h	h			
t5				f		f	h	h	h	h	h	h	h	h	h	h	h	h		
t6						h	f	h	h	h	h	h	h	h	h	h	h	h		
t7						h	h	f	h	h	h	h	h	h	h	h	h	h		
t8						h	h	h	f	h	h	h	h	h	h	h	h	h		
t9						h	h	h	h	f	h	h	h	h	h	h	h	f		
t10											f	h	h	h	h	h	h			
t11												f	h	h	h	h	h			
t12													f	h	h	h	h			
t13														f	h	h	f			
t14														n	f	f	l			
t15															n	f				
t16															l	n				
t17														l	n	f	n			
t18					h	h	h	h	h	h	h	f	h	h	h	h	h	h		
int1	f	f	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h		
int2	h		f	f	h	h	h	h	h	h	h	h	h	h	h	h	h	h		

Conclusion-test dependency

	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14	t15	t16	t17	t18	int1	int2
int1	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	f	
int2	h		h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h		f
c1	f			h									h	h	h	h	h			
c2	f			h									h	h	h	h	h			
c3	h	f	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h		
c4	h		f	h	h	h	h	h	h	h	h	h	h	h	h	h	h	h		
c5				h	f	h	h	h	h	h	h	h	h	h	h	h	h	h		
c6	f			h	f	h	h	h	h	f	h	h	h	h	h	h	h	h		
c7						f	h	h	h	h	h	h	h	h	h	h	h	h		
c8						h	f	h	h	h	h	h	h	h	h	h	h	h		
c9						h	h	f	h	h	h	h	h	h	h	h	h	h		
c10						h	h	h	f	h	h	h	h	h	h	h	h	h		
c11										f	h	h	h	h	h	h	h			
c12										f	h	h	h	h	h	h	h			
c13																				
c14											f	h	h	h	h	h	h			
c15												f	h	h	h	h	h			
c16													f	h	h	h	h			
c17													f	h	h	h	h			
c18													f	h	h	h	h			
c19														f	h	h	f			
c20															f	f				
c21				f									h	h	h	h	h			
inu1														f	f	f	h			
inu2													f	h	h	h	h			
NF																				

Result Evaluation

Test-test dependency

	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14	t15	t16	t17	t18	int1	int2
t1				1											1	1	1			
t2	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
t3	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
t4													1	1	1	1	1			
t5				1		1	1	1	1	1	1	1	1	1	1	1	1	1		
t6						1	1	1	1	1	1	1	1	1	1	1	1	1		
t7						1	1	1	1	1	1	1	1	1	1	1	1	1		
t8						1	1	1	1	1	1	1	1	1	1	1	1	1		
t9						1	1	1	1	1	1	1	1	1	1	1	1	1		
t10											1	1	1	1	1	1	1			
t11												1	1	1	1	1	1			
t12													1	1	1	1	1			
t13														1	1	1	1			
t14														1	1	1	1			
t15															1	1				
t16															1	1				
t17														1	1	1	1			
t18					1	1	1	1	1	1	1	1	1	1	1	1	1	1		
int1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
int2	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		

Test signature

Conclusion-test dependency

	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14	t15	t16	t17	t18	int1	int2	
int1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		Syndrome
int2	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	
c1	1			1									1	1	1	1	1				
c2	1			1									1	1	1	1	1				
c3		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
c4	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
c5				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
c6	1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1			
c7						1	1	1	1	1	1	1	1	1	1	1	1	1			
c8						1	1	1	1	1	1	1	1	1	1	1	1	1			
c9						1	1	1	1	1	1	1	1	1	1	1	1	1			
c10						1	1	1	1	1	1	1	1	1	1	1	1	1			
c11										1	1	1	1	1	1	1	1				
c12										1	1	1	1	1	1	1	1				
c13																					undetected failure
c14											1	1	1	1	1	1	1				
c15												1	1	1	1	1	1				
c16													1	1	1	1	1				
c17													1	1	1	1	1				Ambiguity group
c18													1	1	1	1	1				
c19														1	1	1	1				
c20															1	1					
c21				1									1	1	1	1	1				
inu1														1	1	1	1				
inu2													1	1	1	1	1				
NF																					

Qualitative Characterization of the System Testability

- **Equivalent fault groups under I:**

		Ambiguity group						
		G1	G2	G3	G4	G5	G6	
RU1	c1	1						
	c3							
RU2	c2	1						
	c21							
RU3	c4							
	c5							
	c6							
RU4	c7		1					
	c8		1					
RU5	c9		1					
	c10		1					
	c11			1				
RU6	c12			1				
	c13				1			No false diagnosis, c13 untested
	c14							
	c15							
RU7	c16					1		false replacement due failure of inu2, c18?
	c17					1		
RU8	c18					1		
	c19						1	
	c20							
inu1							1	
inu2						1		
int1								
int2								
NF					1			
		RU1, RU2	RU4, RU5	RU5, RU6	RU6, NF	RU7,RU8, inu2	RU8,inu1	

- **Measures**
  - **Objects**
    - **Fault isolation**
    - **Test set**
  - **Weights**
    - **Combinatorial**
    - **Failure rates -> probability / mean value**
    - **Costs -> cost estimator**
- **Fault isolation measures**
  - **Fault coverage**
  - **Isolation level: $|\text{Syndromes}| / |\text{Failures}| \leq 1$**
  - **Operational isolation:**
    - **Ratio of faults resulting in an isolation of maximal n RU ≤ 1**
    - **n=2 $|\{c3,c4,c5,c6,c14,c15,c20,c21\} \cup G1 \cup G2 \cup G3 \cup G4 \cup G6| / |F| = 22/26$**
- **Test set measures**
  - **Test leverage** $\log_2|F| / |F| \leq |\text{Tests}| / |\text{Failures}| \leq |F| / (|F|-1)$
    - **Modified versions by omission of**
      - **inputs**
      - **feedback**
  - **Test uniqueness**
    - **Identical syndromes** $|UI| / |I|$
  - **Test redundancy**
    - **Identical test signatures**
    - **Non-redundant test leverage**

- **False alarm tolerance**
  - **Check t_x by performing $\forall t_y \in D(t_x)$**

    FAT= |1 in the t_x row of the test-to-test dependency matrix | / [|I| * (|I|+1)]
- **Multiple failures**
  - **Hidden**
  - **False**

- **Excess tests**
  - **Increase of ambiguity (conclusion or RU), if a test omitted**

	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14	t15	t16	t17	t18	int1	int2
int1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
int2	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1
c1	1			1									1	1	1	1	1			
c2	1			1									1	1	1	1	1			
c3	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
c4	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
c5				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
c6	1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
c7						1	1	1	1	1	1	1	1	1	1	1	1	1		
c8						1	1	1	1	1	1	1	1	1	1	1	1	1		
c9						1	1	1	1	1	1	1	1	1	1	1	1	1		
c10						1	1	1	1	1	1	1	1	1	1	1	1	1		
c11										1	1	1	1	1	1	1	1			
c12										1	1	1	1	1	1	1	1			
c13																				
c14											1	1	1	1	1	1	1			
c15												1	1	1	1	1	1			
c16													1	1	1	1	1			
c17													1	1	1	1	1			
c18													1	1	1	1	1			
c19														1	1	1	1			
c20															1	1				
c21				1									1	1	1	1	1			
inu1														1	1	1	1			
inu2													1	1	1	1	1			
NF																				

Diagnosis and fault isolation

- **Sequencing of the test set in order to minimize test length**
  - **Combinatorial explosion**
- **Traditional approaches**
  - **Directed (backtrace):**
    Backwards from the first known fault site
  - **Half-interval:**
    Test at the middle of the system
    - **Halfway towards inputs, if failed**
    - **Halfway towards outputs if passed**
  - **Half-interval directed:**
    Test at the middle of the system
    - **Backtrace towards inputs, if failed**
    - **Half-interval towards outputs if passed**
  - **Half-interval with pretest:**
    - **Test inputs and outputs**
      - **If both pass then NF**
      - **If input fails then input fault**
      - **Else test at the middle of the system etc.**
  - **Exponential**
    Same as half-interval, but 63%
  - **Exponential directed**

New approach: adaptive entropy-directed diagnosis

- **Goal: each test minimize the uncertainty in the system**
- **Maximization of the information content: NP-complete**
- **Information from a test outcome t_x**
  - **Passes:**
    - $t_x=0$
    - $\forall t : (t \in D^{-1}(t_x)) \wedge (t=u) \rightarrow (t=0)$
  - **Fails:**
    - $t_x=1$
    - $\forall t : (t \in D(t_x)) \wedge (t=u) \rightarrow (t=1)$
    - **Single fault assumption**
      - $\forall t : (t \notin (D(t_x) \cup D\text{-}1(t_x)) \wedge (t=u) \wedge$ **t excess test** $\rightarrow$ **t can be omitted**
- **Test selection:**
  - **Min-max algorithm on the count of conclusions from passed/failed**
  - **Tiebreakers**
    - **max max**
    - **lexicographic**

Weighted by practical parameters

- Direct: test-related
  - Cost
  - Time
  - Skill
- Direct: component-related
  - Failure frequency
  - Criticality

Fault tree:

- DFS in the test outcomes

Basic Table

Test-test dependency

	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14	t15	t16	t17	t18	int1	int2
t1				1											1	1	1			
t2	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
t3	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
t4													1	1	1	1	1			
t5				1		1	1	1	1	1	1	1	1	1	1	1	1	1		
t6						1	1	1	1	1	1	1	1	1	1	1	1	1		
t7						1	1	1	1	1	1	1	1	1	1	1	1	1		
t8						1	1	1	1	1	1	1	1	1	1	1	1	1		
t9						1	1	1	1	1	1	1	1	1	1	1	1	1		
t10											1	1	1	1	1	1	1			
t11												1	1	1	1	1	1			
t12													1	1	1	1	1			
t13														1	1	1	1			
t14														1	1	1	1			
t15															1	1				
t16															1	1				
t17														1	1	1	1			
t18					1	1	1	1	1	1	1	1	1	1	1	1	1	1		
int1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
int2	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		

Conclusion-test dependency

	t1	t2	t3	t4	t5	t6	t7	t8	t9	t10	t11	t12	t13	t14	t15	t16	t17	t18	int1	int2
int1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
int2	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1
c1	1			1									1	1	1	1	1			
c2	1			1									1	1	1	1	1			
c3		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
c4	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
c5				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
c6	1			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
c7						1	1	1	1	1	1	1	1	1	1	1	1	1		
c8						1	1	1	1	1	1	1	1	1	1	1	1	1		
c9						1	1	1	1	1	1	1	1	1	1	1	1	1		
c10						1	1	1	1	1	1	1	1	1	1	1	1	1		
c11										1	1	1	1	1	1	1	1			
c12										1	1	1	1	1	1	1	1			
c13																				
c14											1	1	1	1	1	1	1			
c15												1	1	1	1	1	1			
c16													1	1	1	1	1			
c17													1	1	1	1	1			
c18													1	1	1	1	1			
c19														1	1	1	1			
c20															1	1				
c21				1									1	1	1	1	1			
inu1														1	1	1	1			
inu2													1	1	1	1	1			
NF																				