

Watchdog Processor for the MEMSY Multiprocessor

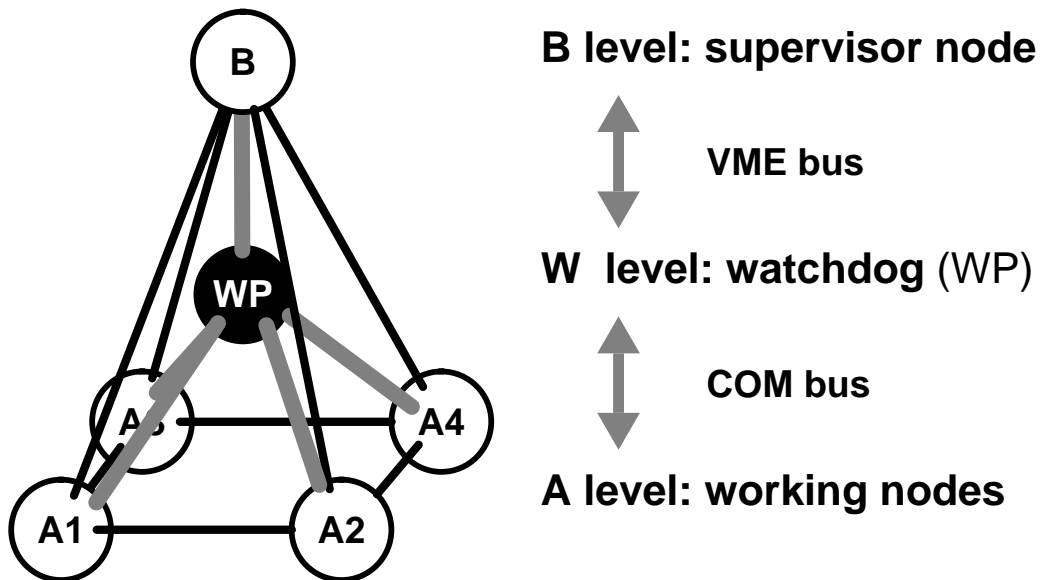
Istvan Majzik

Main features:

- 1. A new signature assignment method:**
***SEIS: Signature Encoded
Instruction Stream***
- 2. Hierarchical checking of the application**
- 3. Integration into the system error recovery**
- 4. Shared use of a single hardware**

System architecture:

Hardware:



Software:

Assigned signatures:

*application programs modified
by the SEIS preprocessor*

Support of error recovery:

*checkpoint generation
rollback recovery* } *in the WP*

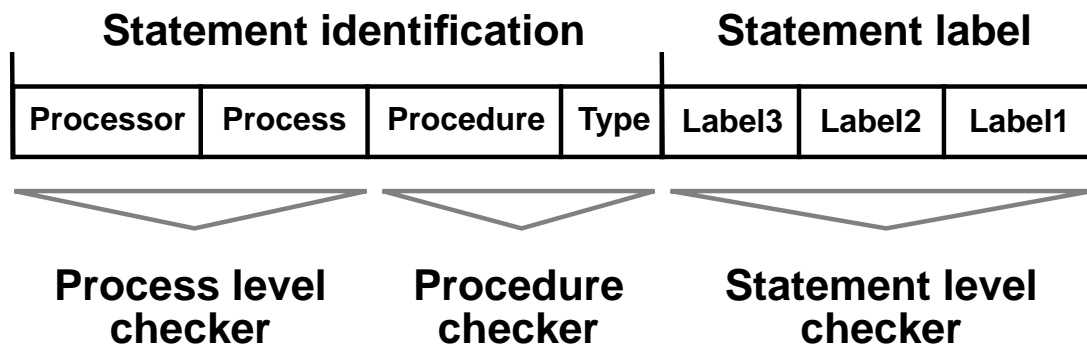
Support of multiprocess systems:

*compile time: unified process ID
run time: unique process ID
(translation: MMU)*

Support of diagnosis:

error log for the supervisor node

Signature structure:



Hierarchical checking:

Statement level checking:

Encoded program control flow graph (CFG)

Signatures identify:

program location +
valid successors

A single reference signature for a CFG

Procedure level checking:

Procedure return:

signature stack in the WP

Process level checking:

Scheduler monitoring

Time-out of the signature transfer

SEIS signature assignment overview:

```

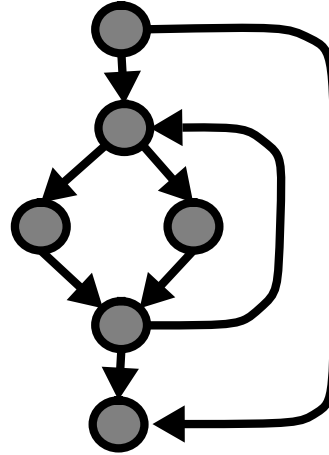
procedure() {
  ● for (i=0; i<MAX; i++) {
    ● if (a>b) {
      ● stat1;}
    else {
      ● stat2;}
    ● }
  ● }
  
```

Watchdog
preprocessor

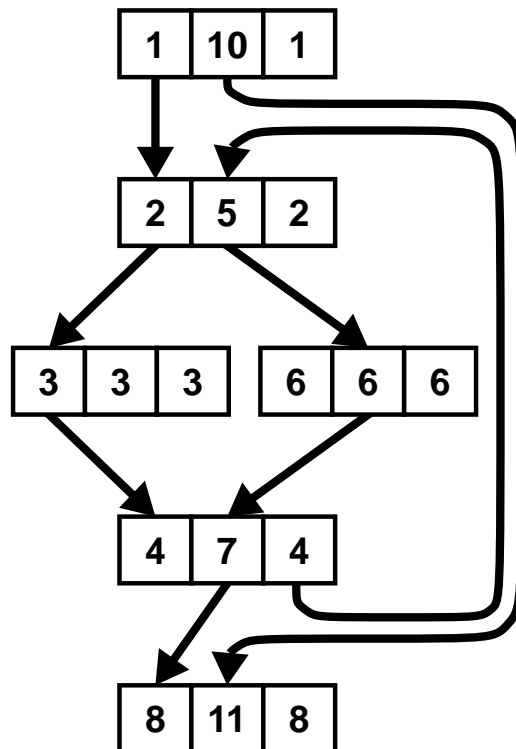
```

procedure() {
  SEND(1,10,1);
  for (i=0; i<MAX; i++) {
    SEND(2,5,2);
    if (a>b) {
      SEND(3,3,3);
      stat1;}
    else {
      SEND(6,6,6);
      stat2;}
    SEND(4,7,4);}
  SEND(8,11,8);
}
  
```

Control graph extraction:

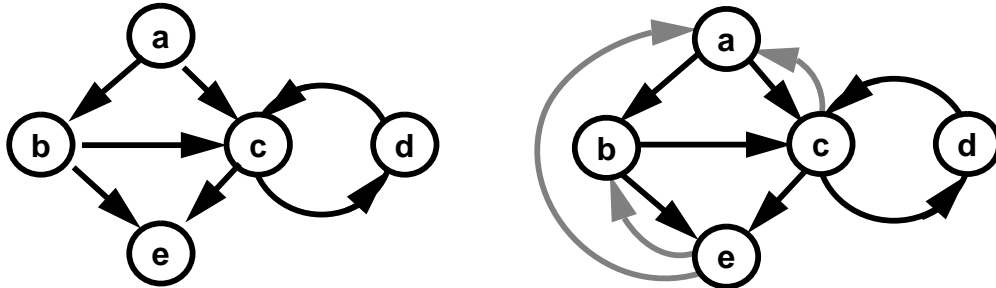


Control graph encoding:

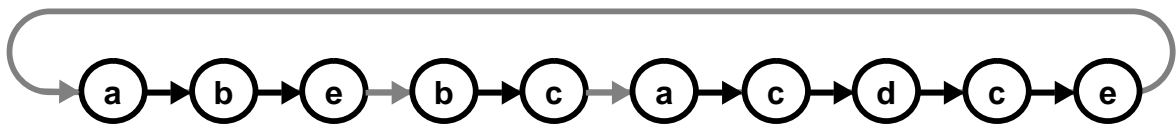


SEIS statement label assignment: CFG processing

- Insert additional edges: → directed Euler graph



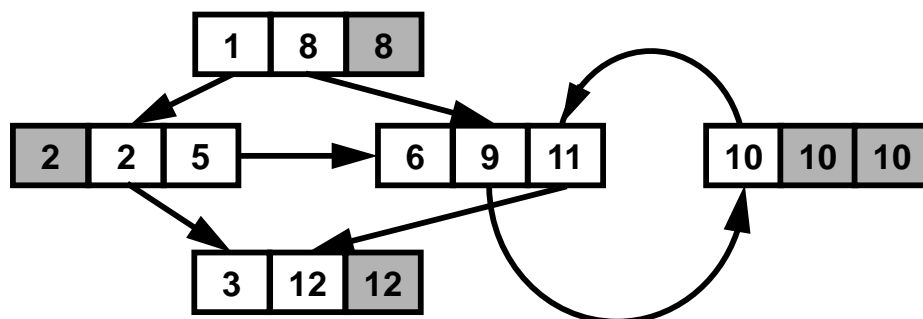
- Compose an Eulerian circuit:



- Encode the edge trails:
 - $c_0=1$ initial
 - $c_{i+1}=c_i+1$ in the trails
 - $c_{i+1}=c_i+2$ start of trails

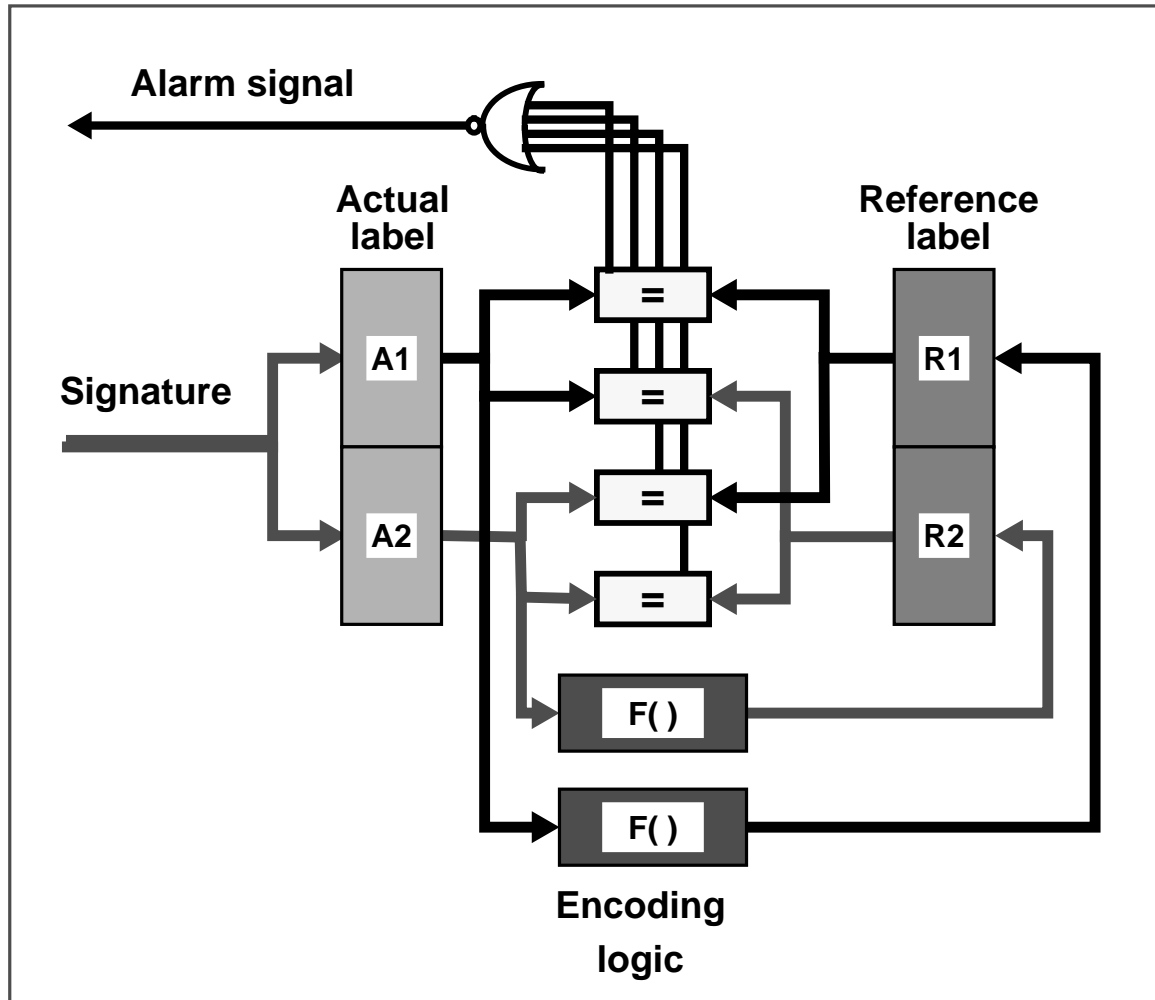


- Compose statement labels:



Statement level checker module:

combinational signature evaluation



here presented for 2 sublabels (A1, A2; R1, R2)

Evaluation:

- compare actual statement label
- update reference label

Valid statement label:

*one of its sublabels is successor of
one of the sublabels of the reference*

Procedure level checking:

Signature type:

- start of procedure (SOP)
- end of procedure (EOP)
- normal signature (NRM)

Signature stack operation in the WP:

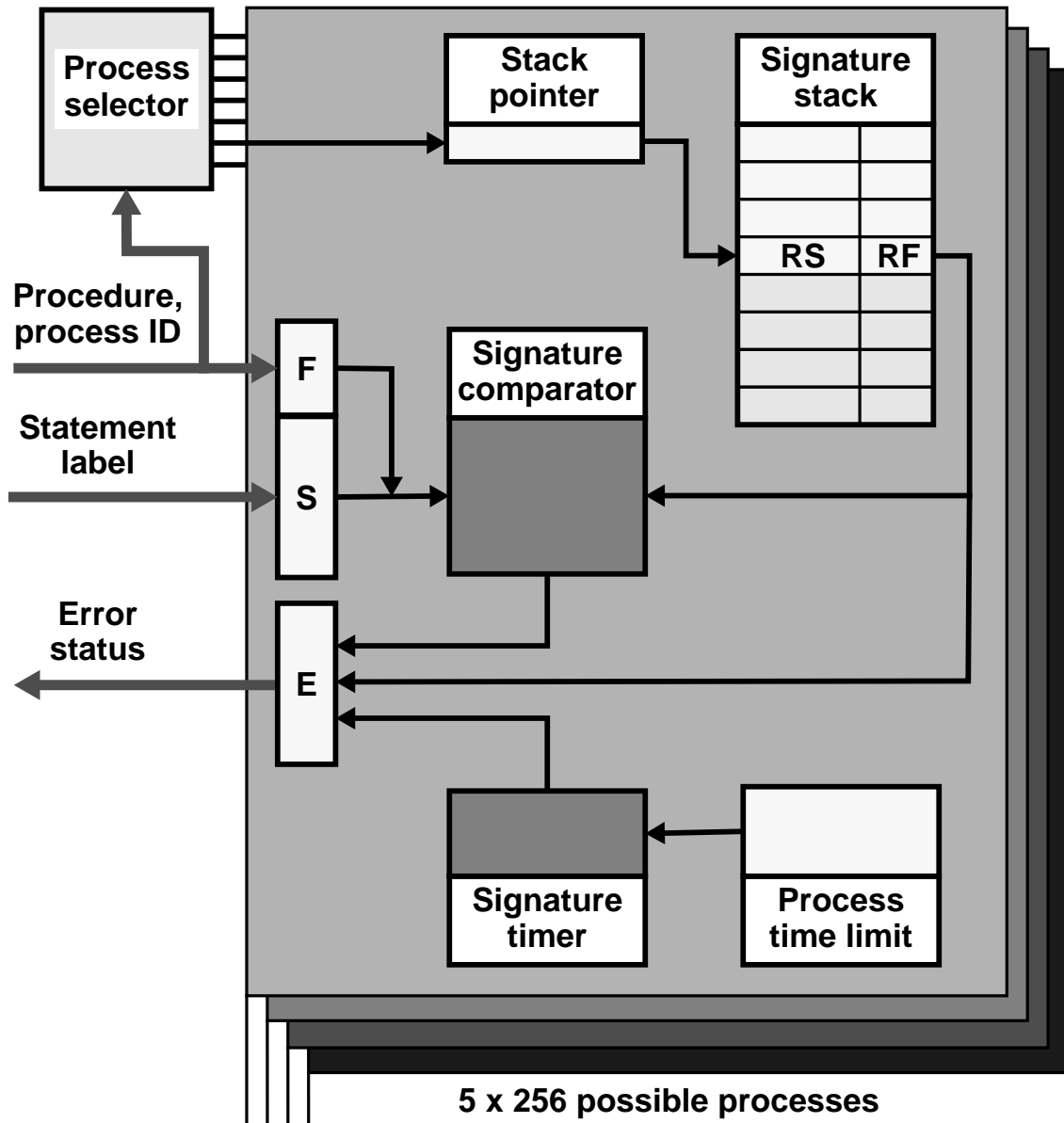
- NRM:** check actual signature
actual signature → new reference
- SOP:** push reference
actual signature → new reference
- EOP:** check actual signature
pop reference

Summary of the checked hierarchy:

		Checked operation	Information
Level	Statement	Statement sequence	Statement label
	Procedure	Procedure return	Signature stack
	Process	Scheduling	Process ID
		Hung process	Signature timer

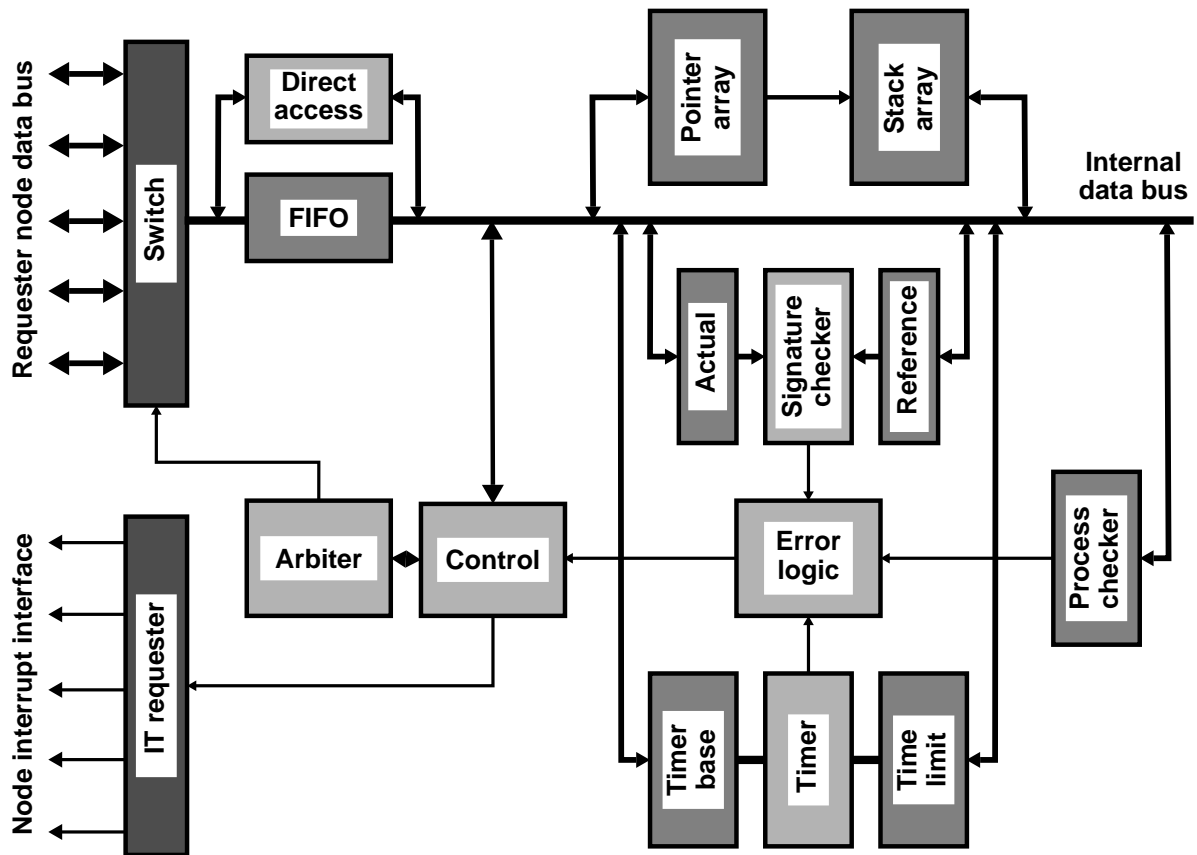
Shared WP hardware:

Multiple logical WP



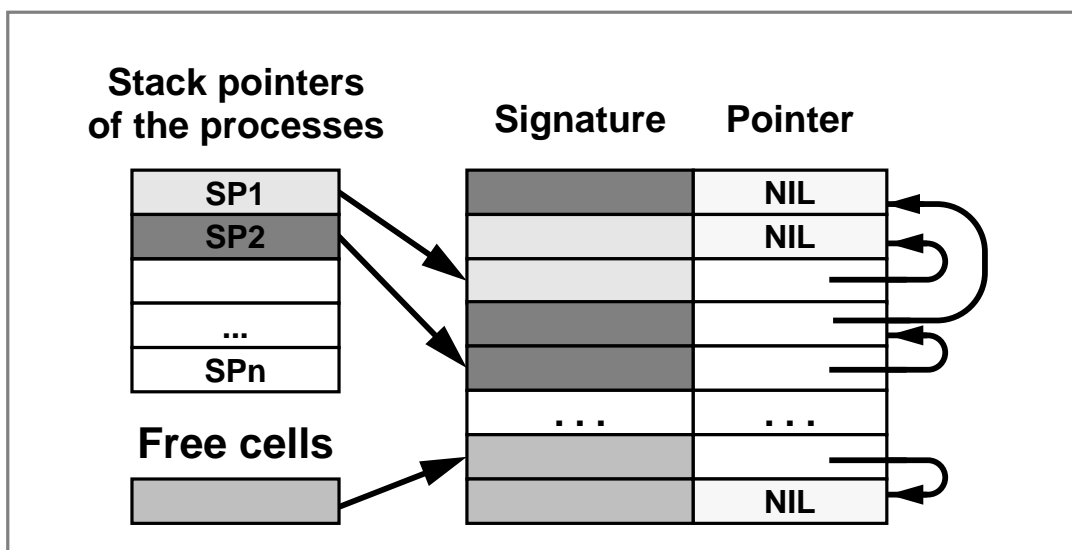
*RS: reference label
RF: reference proc. ID*

Internal hardware architecture:

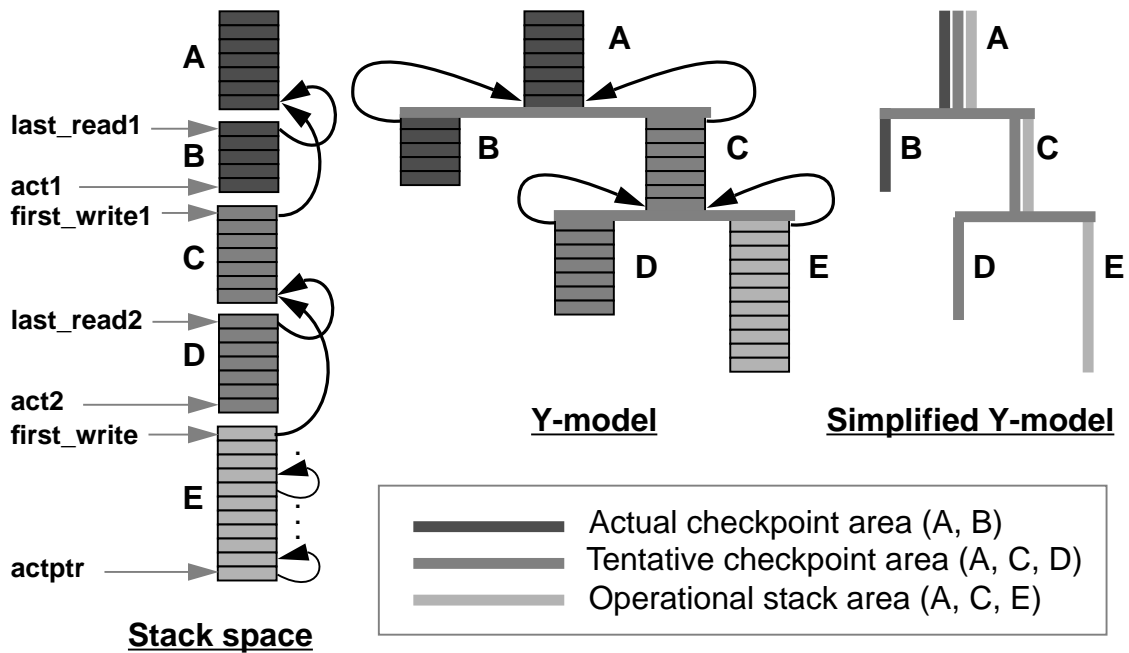


Shared resources:

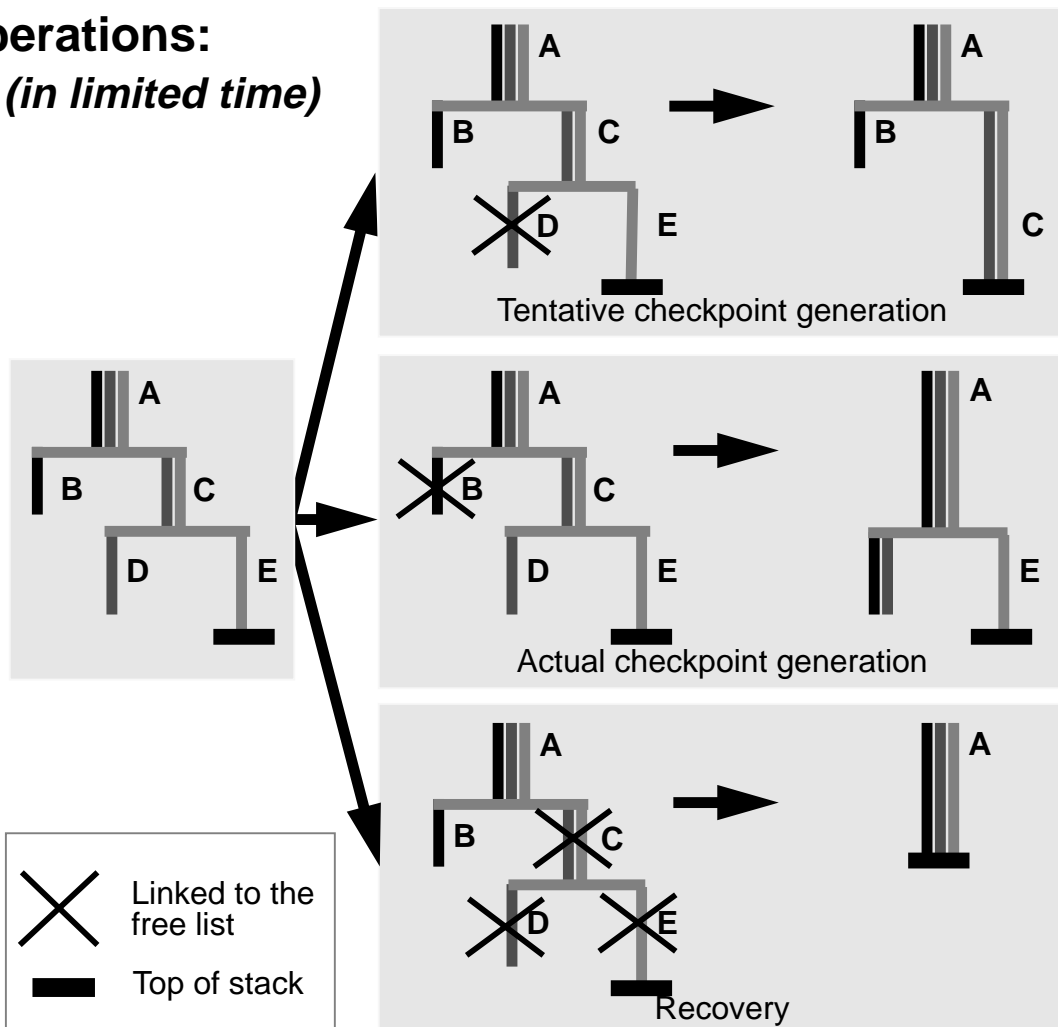
Dynamic splitting of the global stack (linked list)



Checkpointing and recovery:



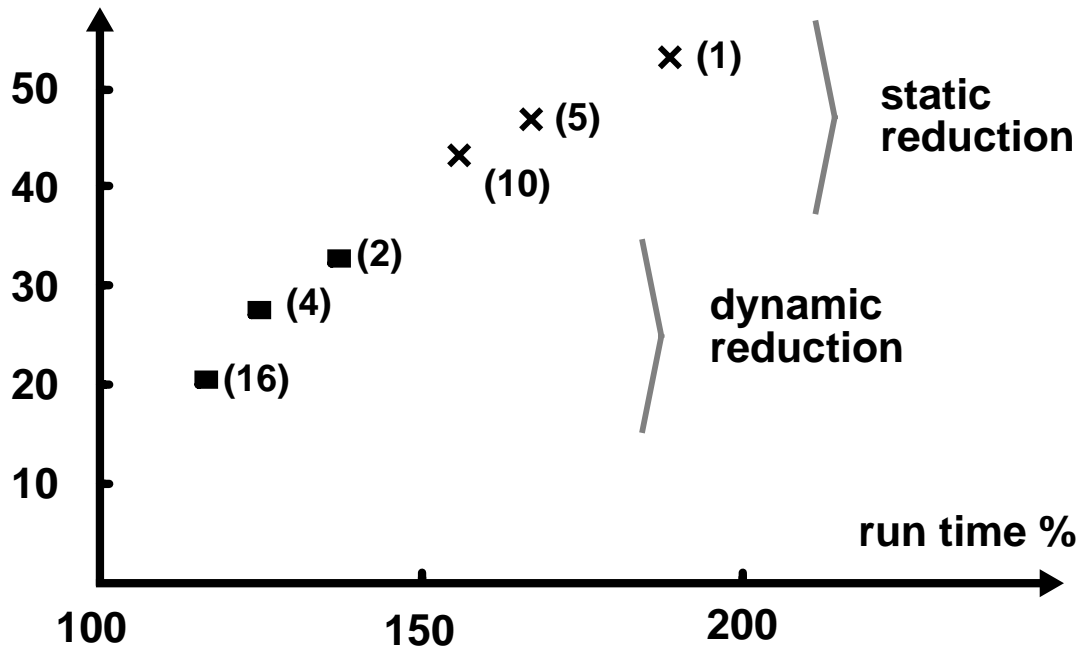
Operations: (in limited time)



Measurement results:

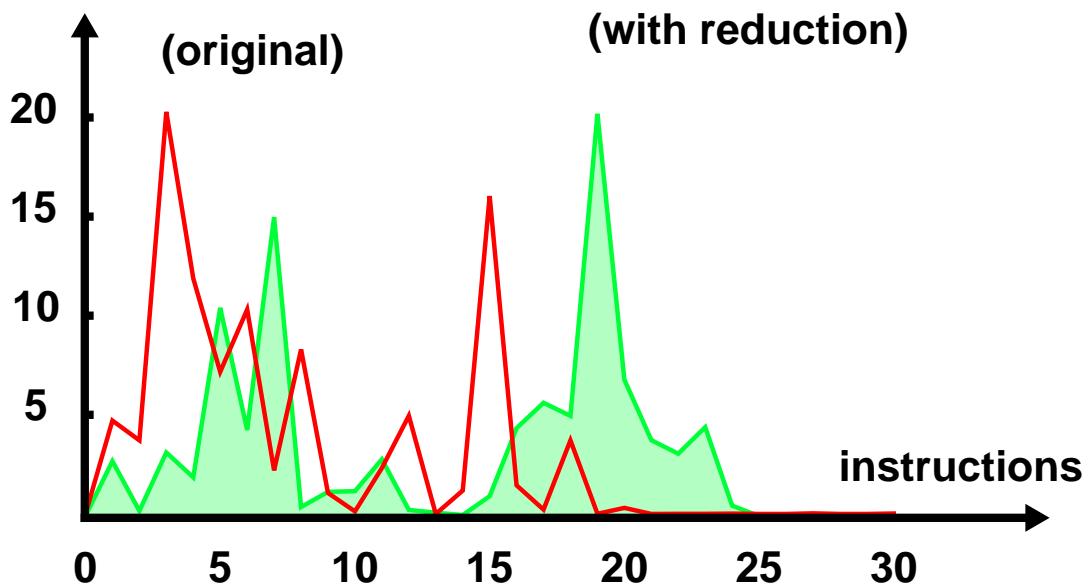
Fault coverage:

fault coverage (% of the previously undetected faults)



Error latency:

signatures (1000)



Conclusions and future work:

Advantages:

- high speed
combinational signature evaluation
- higher-level checks
hierarchical checker modules
- easy integration
hw: uniform signature interface
sw: preprocessors for different languages
support of error recovery

To be improved:

- tuning the signature transfer rate
ideal case: uniform time periods
real case: rough granularity
Solution: weighting CFG with *execution times*
(intermediate compiler level)
- sophisticated test of synchronization
(process algebra modelling)

To be measured:

- performance in the multiprocessor