Idealised Fault Tolerant Architectural Element

Rogério de Lemos
University of Kent, UK

- Motivation – architectural fault tolerance;
- iFTE & propagation of exceptions;
- Case study – mining control system;
- Conclusions & future work;

KENT
UNIVERSITY OF KENT
AT CANTERBURY

Motivation

Architectures are about structures:

- unstructured approaches can reduce system dependability by introducing more faults;
- a good architecture should promote error confinement;

Architectural fault tolerance:

- avoid the failure of systems
  - error detection and handling;
  - fault handling;
- components need to collaborate for handling certain failure scenarios;

KENT
UNIVERSITY OF KENT
AT CANTERBURY

Idealised Fault Tolerant Component

An architectural solution based on exception handling:

- ***idealised fault tolerant component*** enables fault tolerance to be built into the system [Anderson & Lee 81]:
  - separation between normal and abnormal behaviour;
  - provided and required services;
  - local, interface and failure exceptions;

KENT
UNIVERSITY OF KENT
AT CANTERBURY

Idealised Fault Tolerant Component

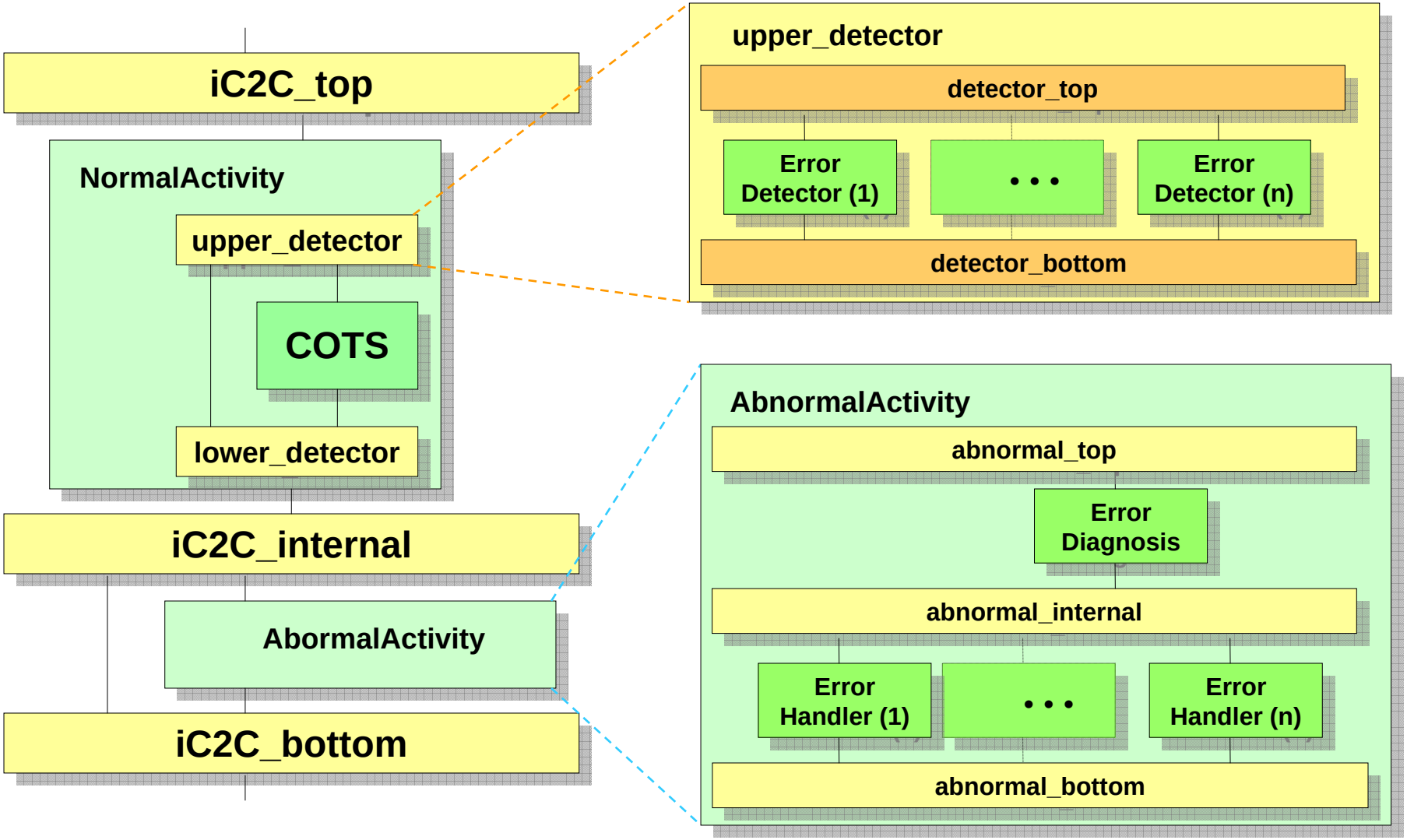
Exception handlers provides mechanisms for:

- handling exceptional conditions so that the exception can be masked;
  - backward recovery – roll back to a previous state;
  - forward recovery – perform actions to correct the state by other means;
- signalling exceptions;

Handlers are provided for anticipated exceptions:

- *default handlers* are provided for unanticipated exceptions;

Idealised Fault Tolerant C2 Component (iC2C)



Idealised Fault Tolerant Architectural Element (iFTE)

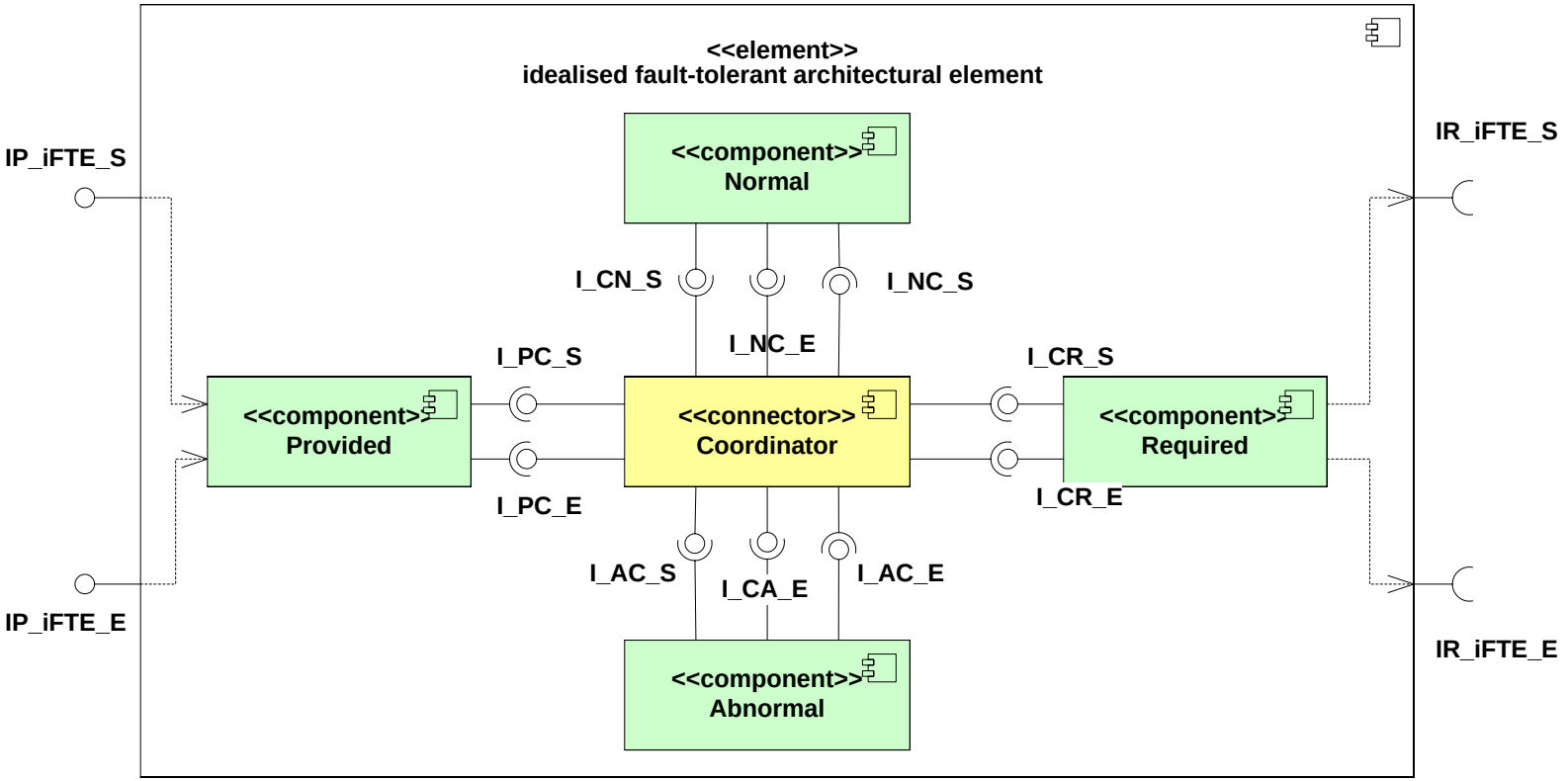
Idealised fault tolerant architectural element (iFTE):

- fault-tolerant software component:
  - preventing the propagation of internal errors by constraining its exceptional behaviour;
- fault-tolerant software connector:
  - coordinating exceptional behaviour among components;
  - resolving potential mismatches;
  - preventing the propagation of errors by handling them as exceptions;

Idealised Fault Tolerant Architectural Element (iFTE)

Architectural solution/pattern:

- peer-to-peer style;
- request/reply interaction;



KENT
UNIVERSITY OF KENT
AT CANTERBURY

iFTE: Propagation Scenarios

Normal behaviour:

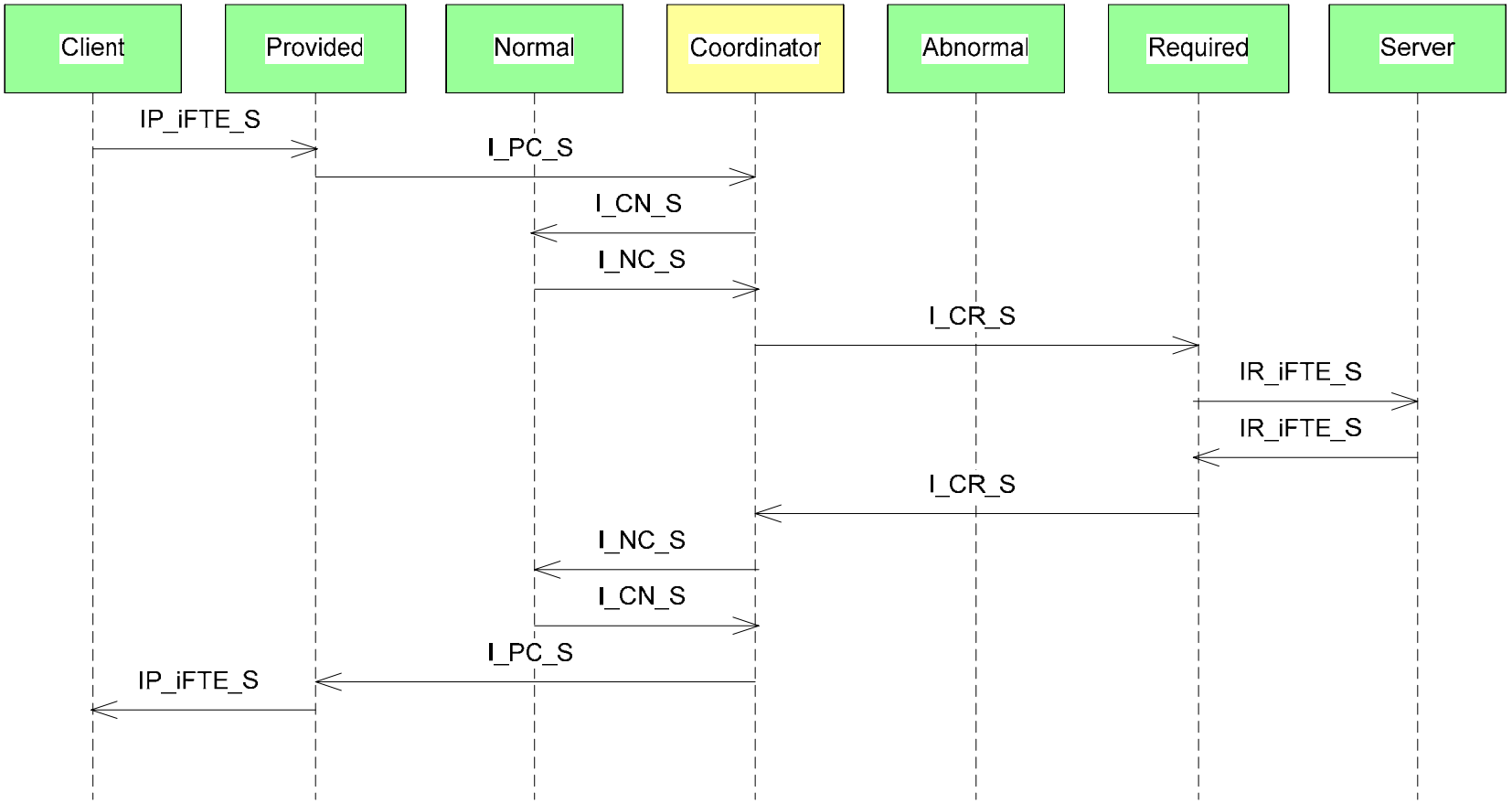
- internal services with no exceptions;
- internal services with exceptions:
  - masked by internal handlers;
  - masked by external handlers;
- requests external services with no exceptions;
- requests external services with exceptions;
  - masked by internal handlers;
  - masked by external handlers;

Exceptional behaviour:

- internal services with exceptions:
  - not masked by internal handlers;
  - not masked by external handlers;
- requests external services with exceptions;
  - not masked by internal handlers;
  - not masked by external handlers;

iFTE: Propagation Scenarios

- normal behaviour when requesting external services with no exceptions;

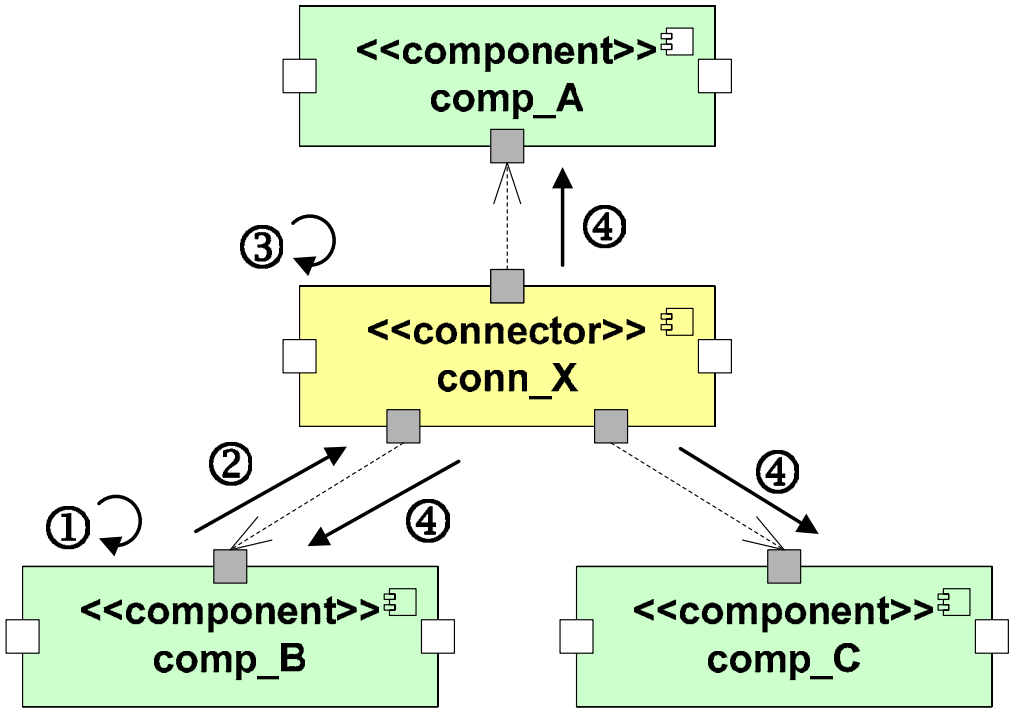


iFTE: Exception Propagation

- contexts for handling exceptions:
  - component, roles and connectors;
- exceptions meaningful for components and connectors;
  - translation on the types of exceptions;

Propagation of exceptions:

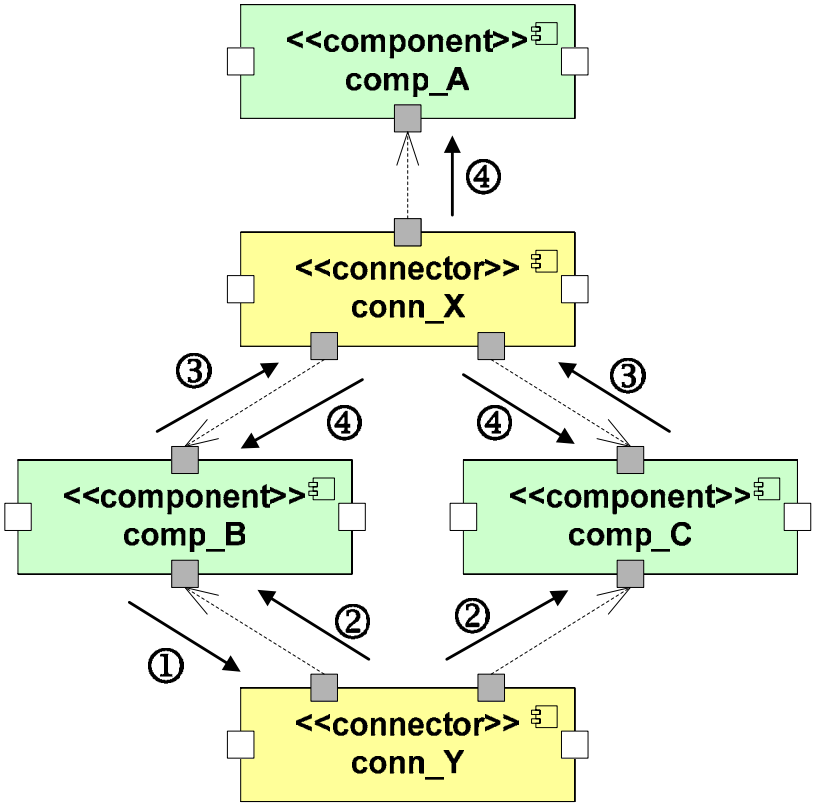
- from components to connectors;
- from connectors to components;



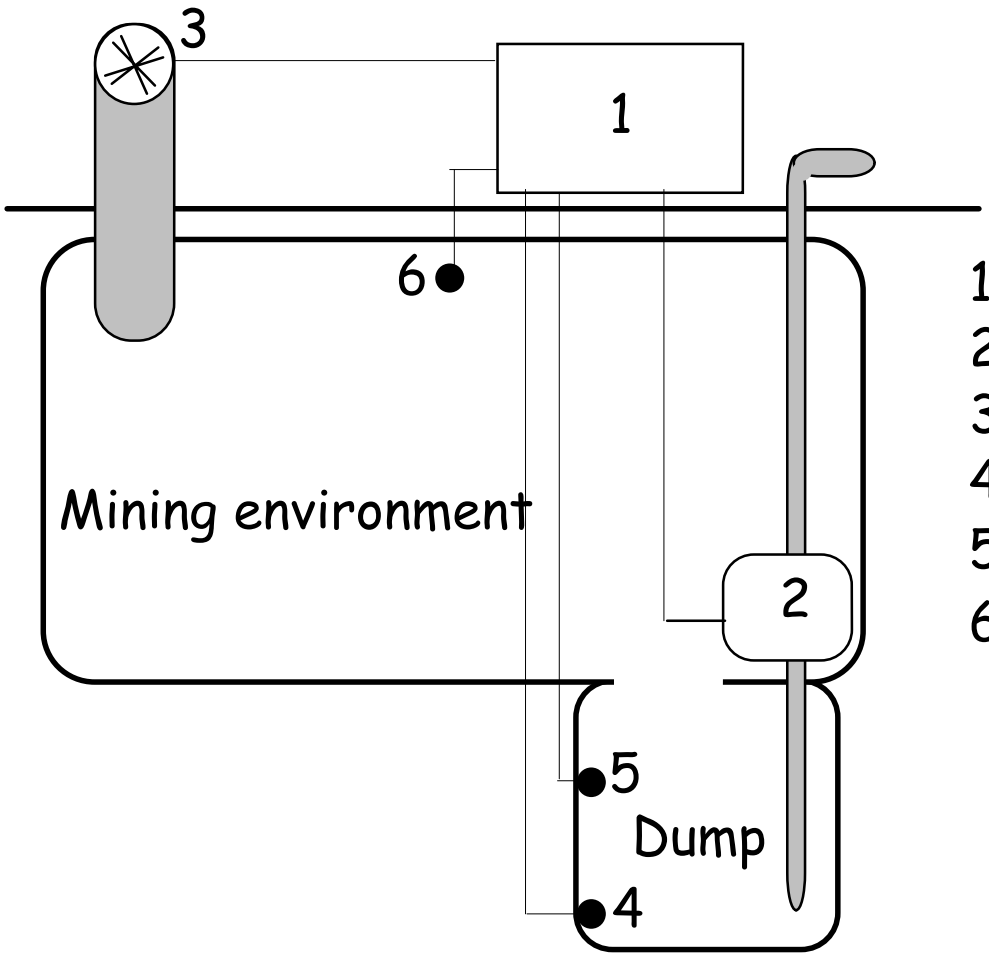
iFTE: Exception Propagation

Propagation of exceptions:

- from connectors to connectors;

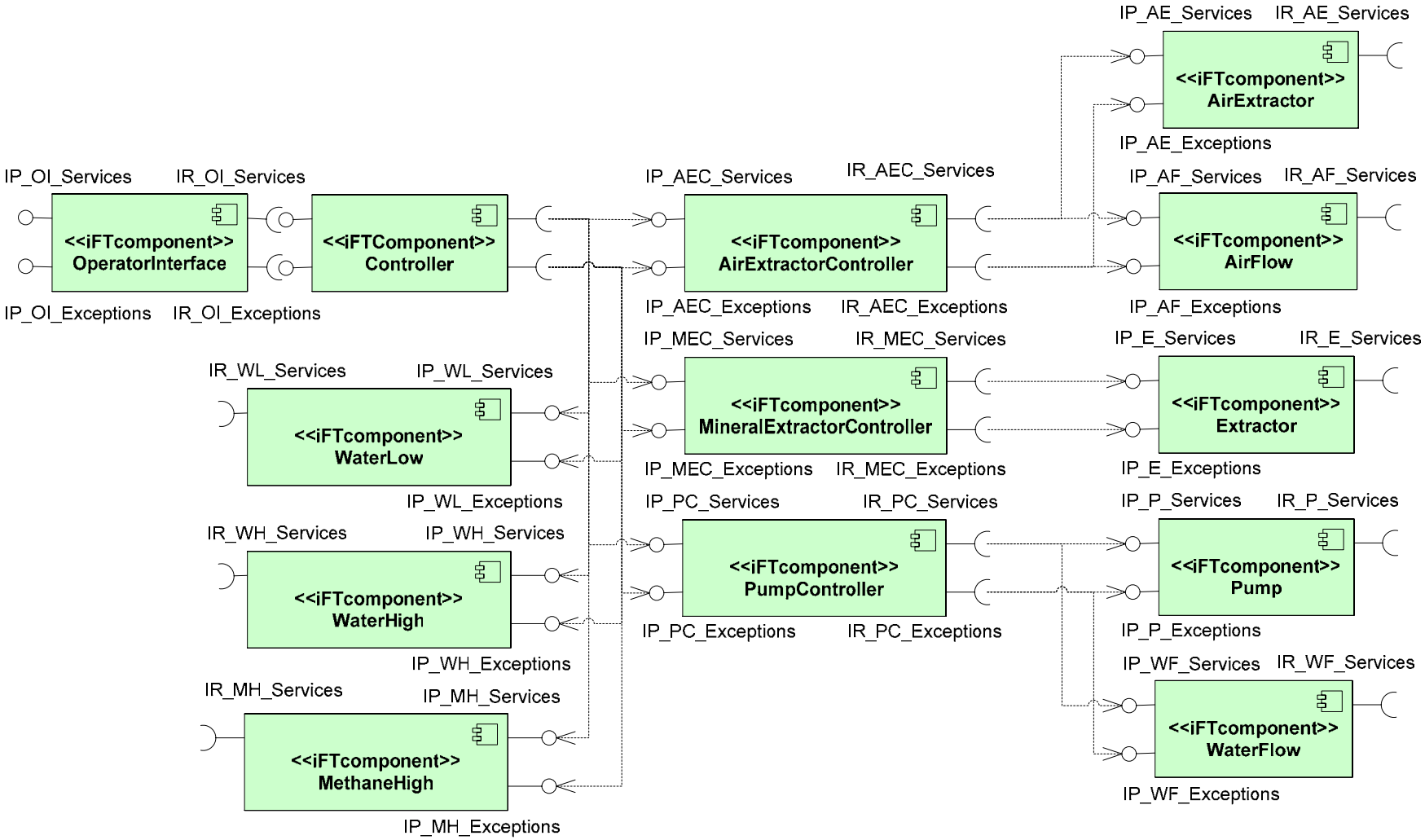


Embedded System: Mining Control System



1- Control system
2- Pump
3- Exhaustor
4- Water sensor (low level)
5- Water sensor (high level)
6- Methan sensor

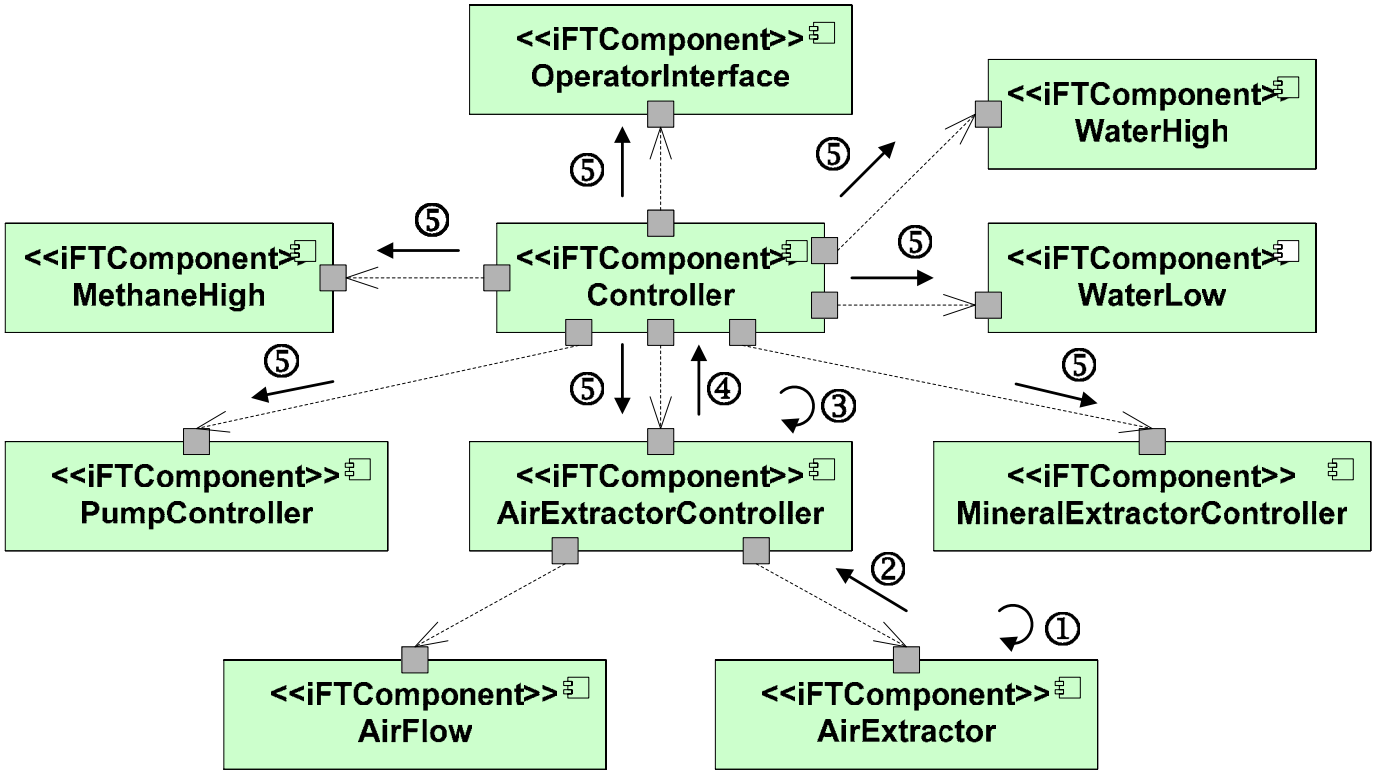
Embedded System: Mining Control System



Embedded System: Mining Control System

Exception propagation when AirExtractor fails exception is propagated to OperatorInterface:

- the whole system shuts down;



KENT
UNIVERSITY OF KENT
AT CANTERBURY

Conclusions

Fault tolerance at the architectural level:

- error detection and handling:
  - application dependent;
  - idealised Fault Tolerant Architectural Elements (iFTE);
    - architectural solution/pattern based on exception handling;
- fault handling:
  - not application dependent;
  - reconfiguration support by CA action;

KENT
UNIVERSITY OF KENT
AT CANTERBURY

Future Work

- model the iFTE with AADL – Error Model;
- iFTE is application dependent and requires additional assurances:
  - model iFTE with B and CSP for analysing the propagation of exceptions;
  - identification of iFTE properties that can be applied to architectures;
  - identification of iFTE test cases;
  - automatic generation of Provided and Required components;