Extended Exception Mechanisms for Contingencies

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Agenda

1. Terms
2. The Problem and Properties of Contingencies
3. Objectives and Proposed Solution
4. Related Work
5. Future Work

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Discovery of contingencies

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- Implement `allocateMemory` when no more main memory is available?
- Don't terminate? Return invalid memory address? Terminate immediately?

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Discovery of contingencies

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- Implement **`allocateMemory`** when no more main memory is available?
- Don't terminate? Return invalid memory address? Terminate immediately?
- Or communicate the **`OutOfMemory`**-Situation?
- **`OutOfMemory`**: availableMemory < requiredMemory

- Fullfilled, but not specified: behaviour undefined
- Specified in callee, excluded in caller: specification contradiction
- Specified and nothing done: caller postconditions violated

- Specify (postcondition) and „signal“ somehow
- Defined and known before runtime
- Unsatisfactory for continuation, handle!

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Definition Contingency

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- An Error is a situation, the conditions of which contradict the specification.
- Error = specification violation = undefined conditions

- Definition Contingency:
  A Contingency is a situation, that is
  - described within the specification of a module, and
  - represents a module result
  - where the task or function, which calling modules depend on, was not performed.
- Usually perceived as errors/specification violation of the caller, but are not the same because conditions defined
- Indicating could or should not fulfill its usual work, work refusal
- Specified, but unsatisfactory
- Potential appearance known in advance

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Current recommendations don't work!

Contingencies:

- Happen in the real world
- Disrupt services, ignoring leads to violations
- Conditions exactly known, should be handled normal
- Handle as part of normal code. Should not be regarded as error.
- How should they be communicated and handled?

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Current recommendations don't work!

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Contingencies:

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Common recommendations:

- Exceptions only for errors, e.g., [Meyer88]
- Declare (special values), e.g., [Bloch03] and redeclare, e.g. [Cristian95]
- Abstract implementation details, e.g., [Bloch03]

Where is the problem?

- Contingencies are omnipresent, accumulate, are implementation dependent and must not be abstracted

Only few? What can happen, when calling ...

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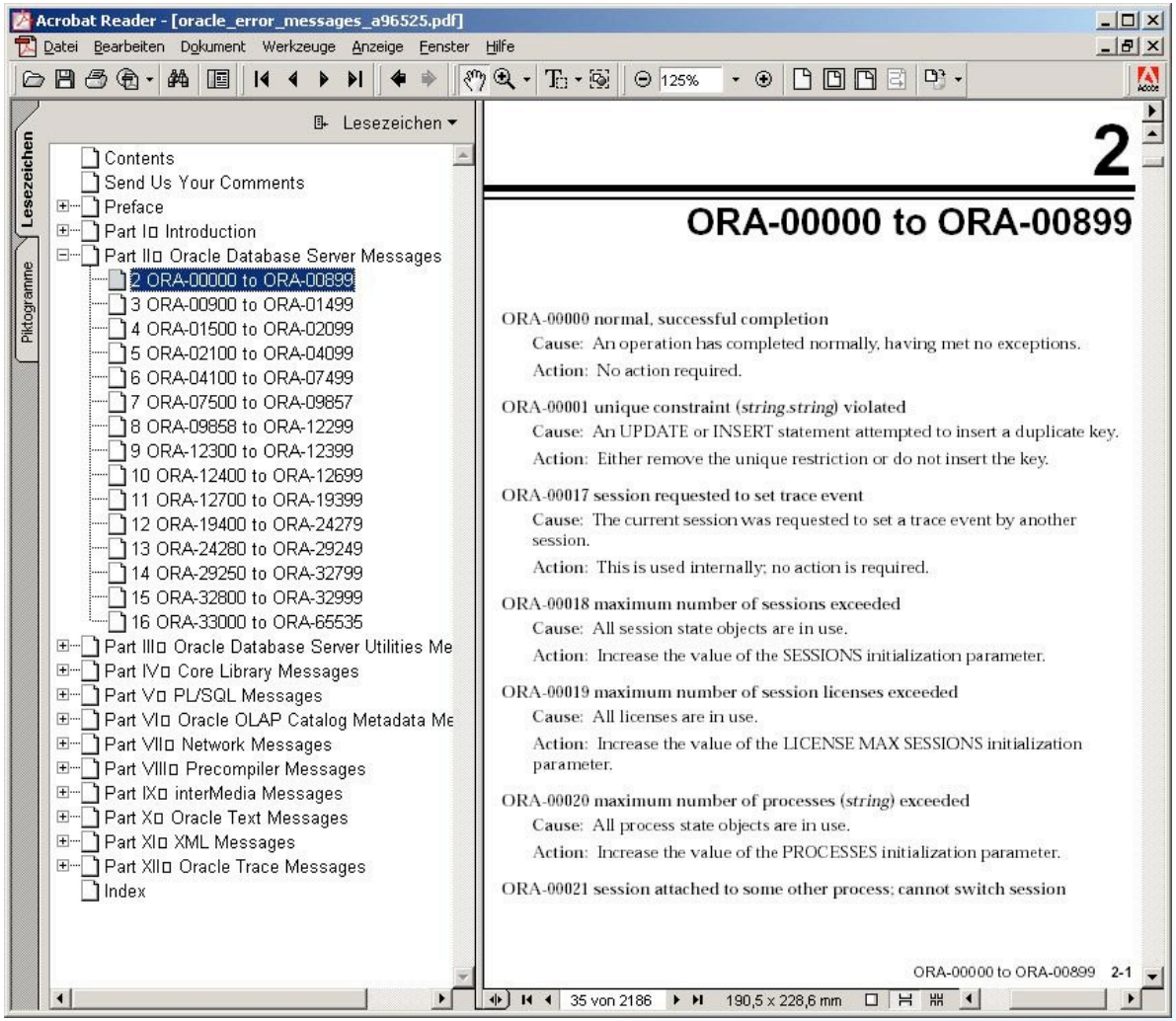
- OpenFile?
  FileNotFound, DirectoryNotFound, DriveNotFound, FileReadOnly, DirectoryReadOnly, DriveReadOnly (HW-Switch), FileNameInvalid, DirectoryNameInvalid, DriveNameInvalid, FileLocked, DriveLocked, MediaNotInserted, MediaNotFormatted, DiskFull, NoAvailableFileHandles, EndOfFile, NetworkDisconnected, QuotaOverflow, DiskEjected, DiskIOError, ...

- ExecuteSQLStatement?
  ColumnNotFound, TableNotFound, SchemaNotFound, DatabaseNotFound, InvalidColumnName, InvalidTableName, InvalidSchemaName, InvalidDatabase, RecordLocked, TableLocked, TableSpaceFull, ...

Systematic problem: contingencies are omnipresent



http://download.oracle.com/docs/cd/B10501_01/server.920/a96525.pdf

- Substantial amounts are contingencies cleanly intercepted and documented at development time

Systematic problem: contingencies accumulate

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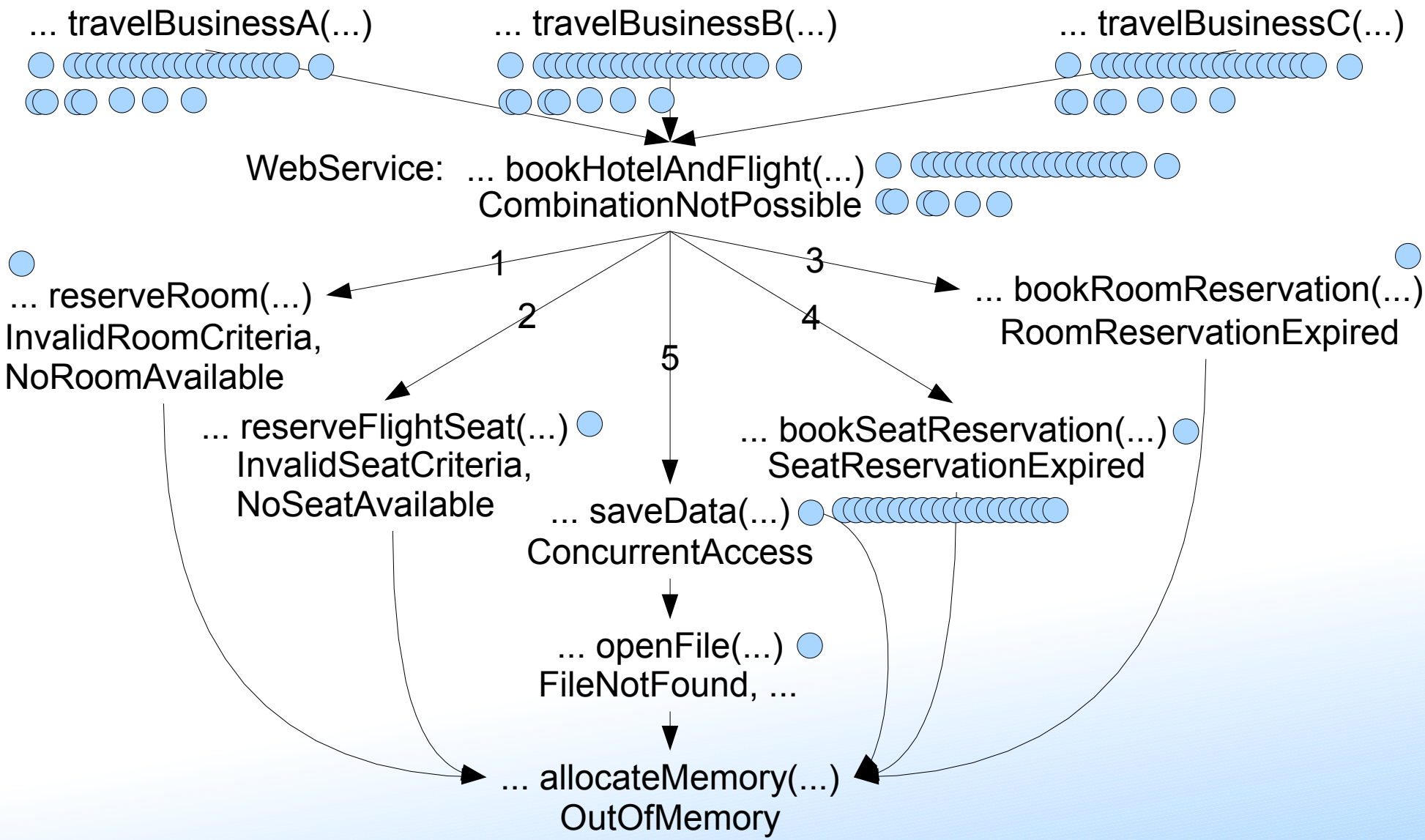
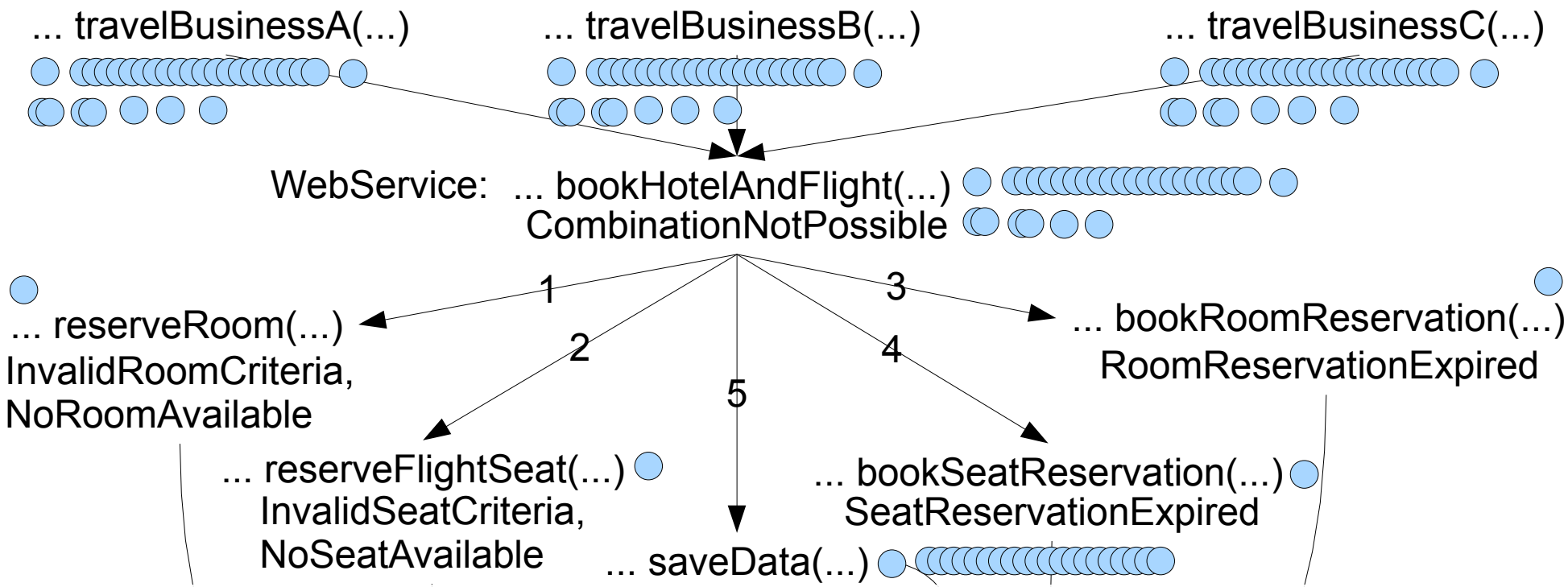
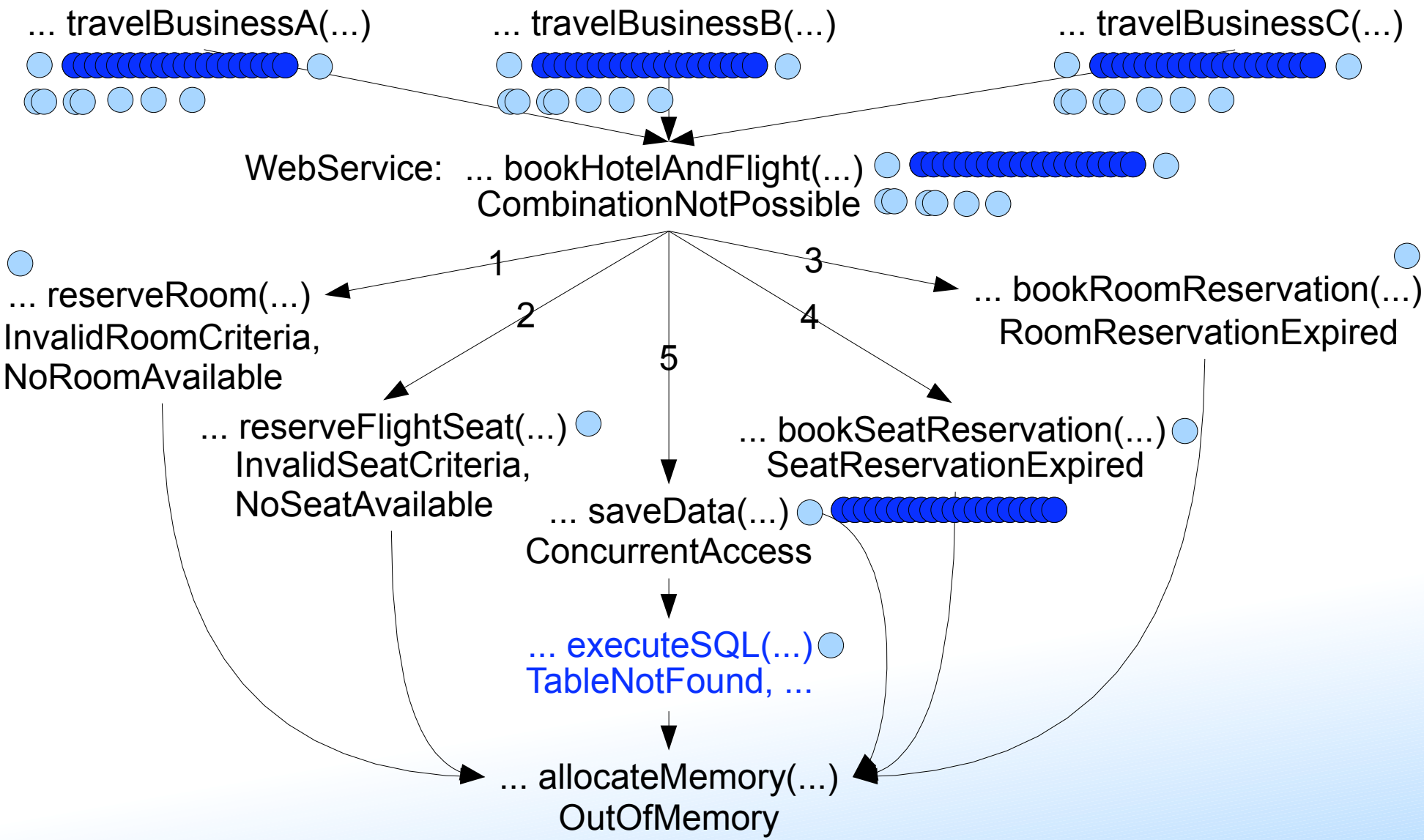


Systematic problem: contingencies accumulate

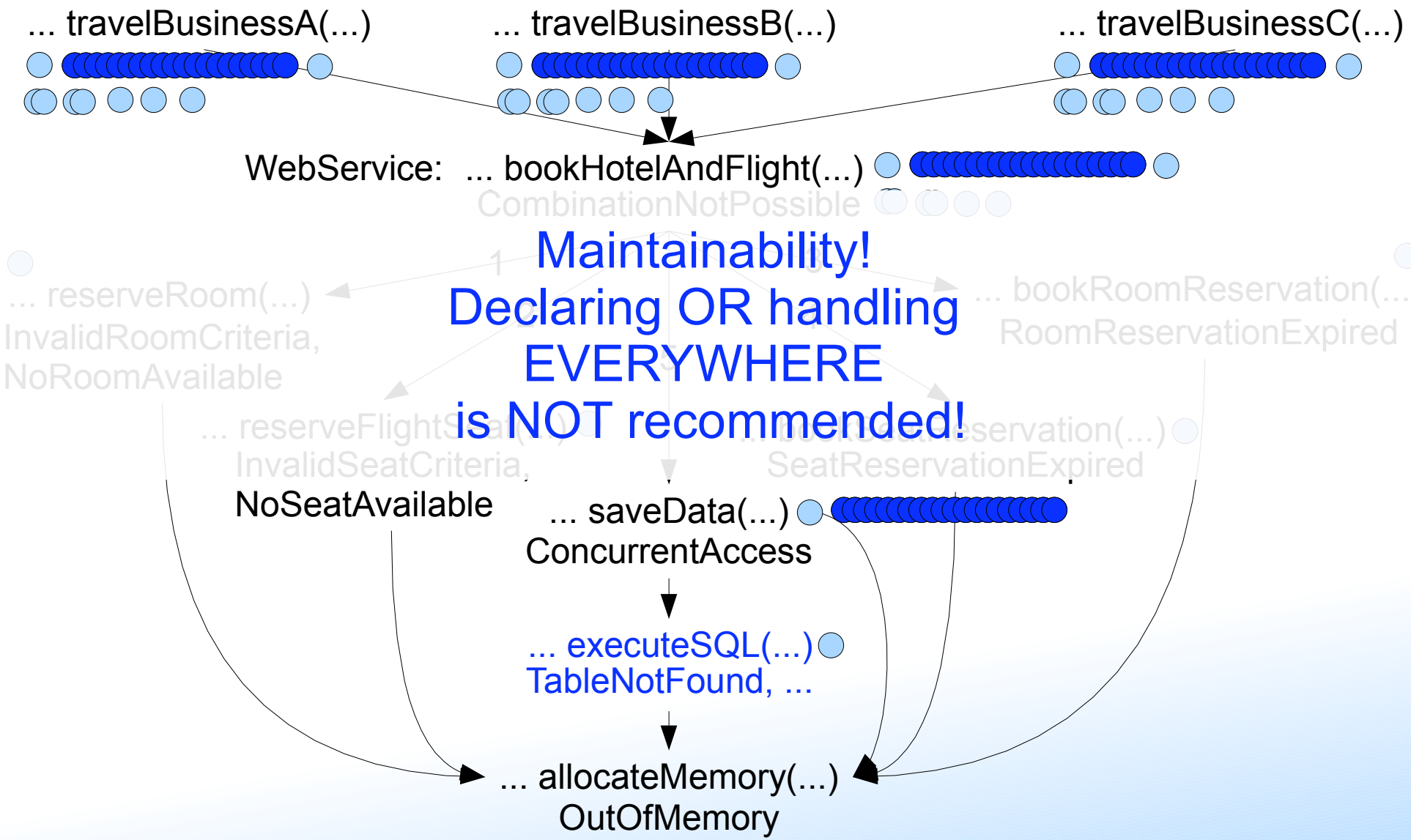


Redundancy!
Declaring OR handling
EVERYWHERE
is NOT recommended!

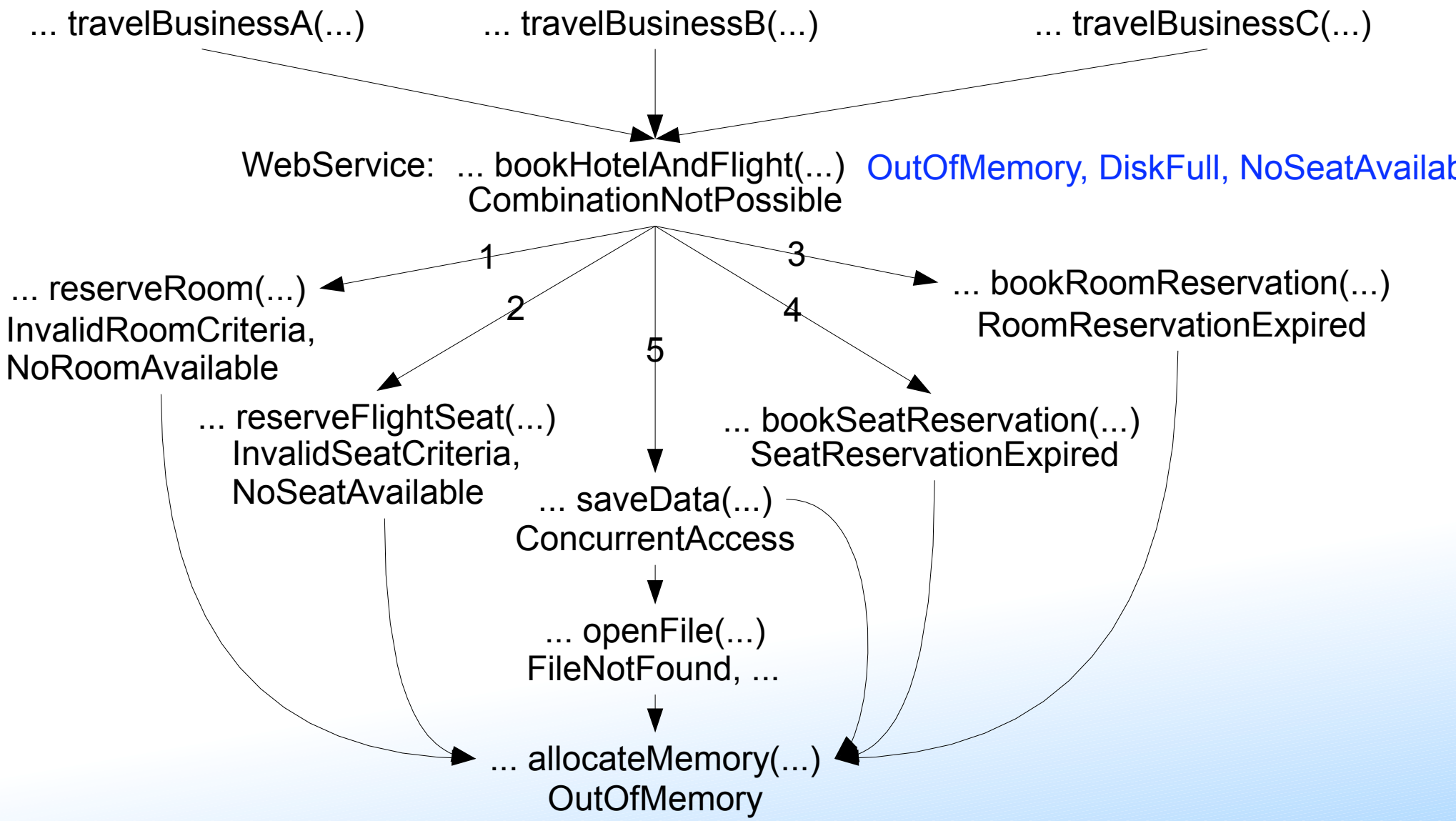
Systematic problem: implementation dependency



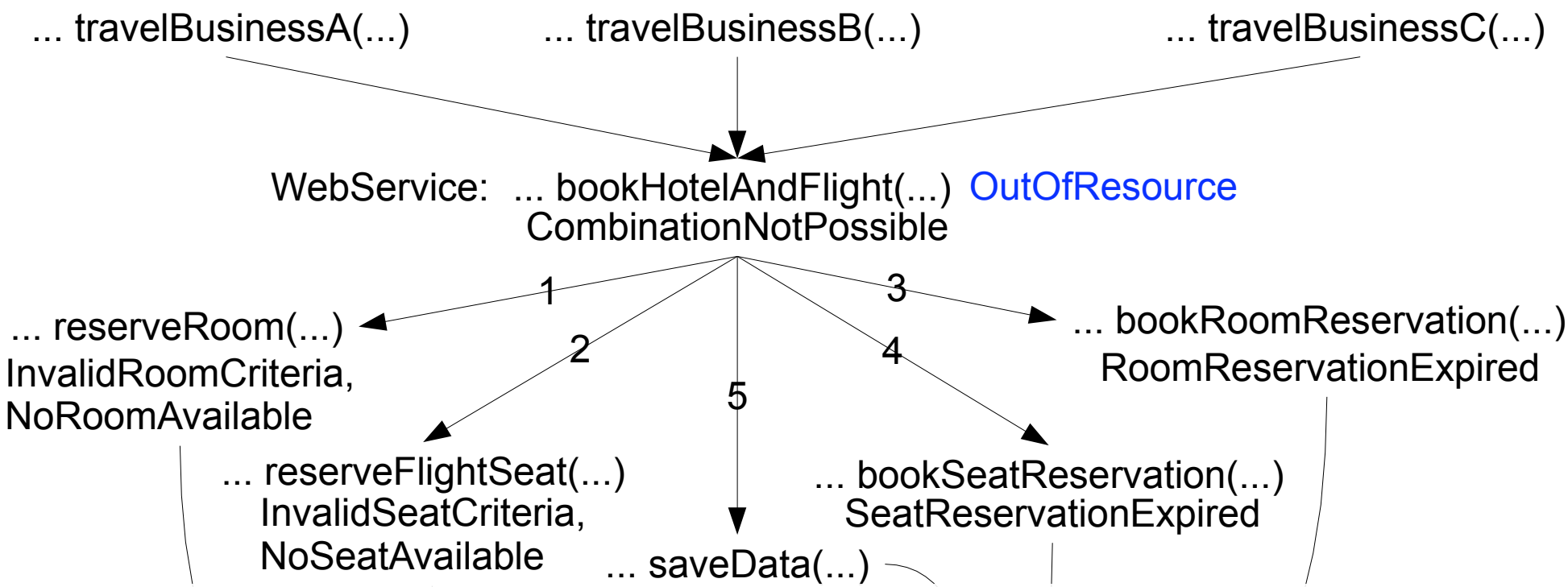
Systematic problem: implementation dependency



Systematic problem: abstraction of implementation is no solution



Systematic problem: abstraction of implementation is no solution



Solution for OutOfMemory: swapping on disk
Solution for DiskFull: select other disk, ...
Solution for OutOfResource?
Abstracting NOT recommended! React specifically!

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Objectives

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- Distinguish contingencies
- Simple communication between the call levels
- Determine automatically at development time
- Get complete documentation of all levels
- Enable forward recovery (ascertaining, repairing, continuing)
  - Even for physical side effects
  - Avoid complications of conventional interfaces
- Enable overriding any handling by outer context with broader knowledge and component access
- Keep information hiding as far as possible

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Overview of solution

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Deficiencies of conventional exception mechanisms

- Ascertaining
- Repairing
- Continuing
- Overriding

Proposed Solution

- Ascertaining interactively
- 3-fold separation (coined by Common Lisp [Pitman90])
- Reversed search order

Handle them, but which?

- Ascertain to handle
- Do you know the contingencies of your last program?
- Can you enumerate them completely?
  E.g., where can DiskFull happen? Why Not?

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Handle them, but which?

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- Ascertain to handle
- Do you know the contingencies of your last program?
- Can you enumerate them completely?
  E.g., where can DiskFull happen? Why Not?

- Conventionally, cannot be ascertained before runtime
- Repair possibilities cannot be applied purposefully before runtime.
- Instead manually in interface, automatic ascertaining
- To be ascertainable contingencies must be marked in the source

Repair by access to implementation details

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Example:

- „DiskFull“ while saving data on disk,
- Regardless, where the problem occurred, raise exception multiple levels
- Let user select alternative path,
- Repair work refusal in lower level, where the problem occurred

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Cooperation and repair of levels

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```
void main(String[] args) { // Within higher layer with GUI-access
      try {
         doTasks(args);
      } catch (HardDiskFull) {
         String alt = AskForAlternativePath.execute().result();
         // set/repair currenPath to alternative, but how/where?
      }
}

void saveEditedData(Data edited) throws HardDiskFull { // No GUI
      if (getFree(currentPath) < edited.size()) {

            throw new HardDiskFull();



      } // ... writing data on disk
}
```

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Cooperation and repair of levels

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```
void main(String[] args) { // Within higher layer with GUI-access
      try {
          doTasks(args);
      } catch (HardDiskFull) {
          String alt = AskForAlternativePath.execute().result();
          solve selectAlternativePath(alt);
      }
}

void saveEditedData(Data edited) throws HardDiskFull { // No GUI
      if (getFree(currentPath) < edited.size()) {
          try {
              throw new HardDiskFull();
          } offer selectAlternativePath(String alternative) {
              currentPath = alternative;
          }

      } // ... writing data on disk
}
```

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Continuing after solution of contingency?

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- Example:
  - Loop over some files
  - Work refusal occurs
  - Good solution exists, but not redundant
  - Raise exception multiple levels
  - Leave loop and unwind stack
  - Solve contingency
- And then? Continuation! But how?
- Which line of the try-block? Try for every line?
- Transactions? For physical side effects?
- Compensation? For ignition of the 2nd propulsion stage?
- Publish internal partial state[Miller97]? Sacrifice information hiding? Interface complications everywhere?
- Additional effort and cost before and at runtime: kind of damage!

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Continuing after solution of contingency?

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- Example:
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  - Good solution exists, but not redundant
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  - Leave loop and unwind stack
  - Solve contingency
- And then? Continuation! But how?
- Which line of the try-block? Try for every line?
- Transactions? For physical side effects?
- Compensation? Programmer must provide code
- Publish internal partial state? Violation of information hiding? Interface complications everywhere?
- Additional effort and cost before and at runtime: kind of damage!

The simplest and most efficient solution(!):
do NOT unwind the stack and
resume at a suitable place:
(Special) resumption!

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Override handling?

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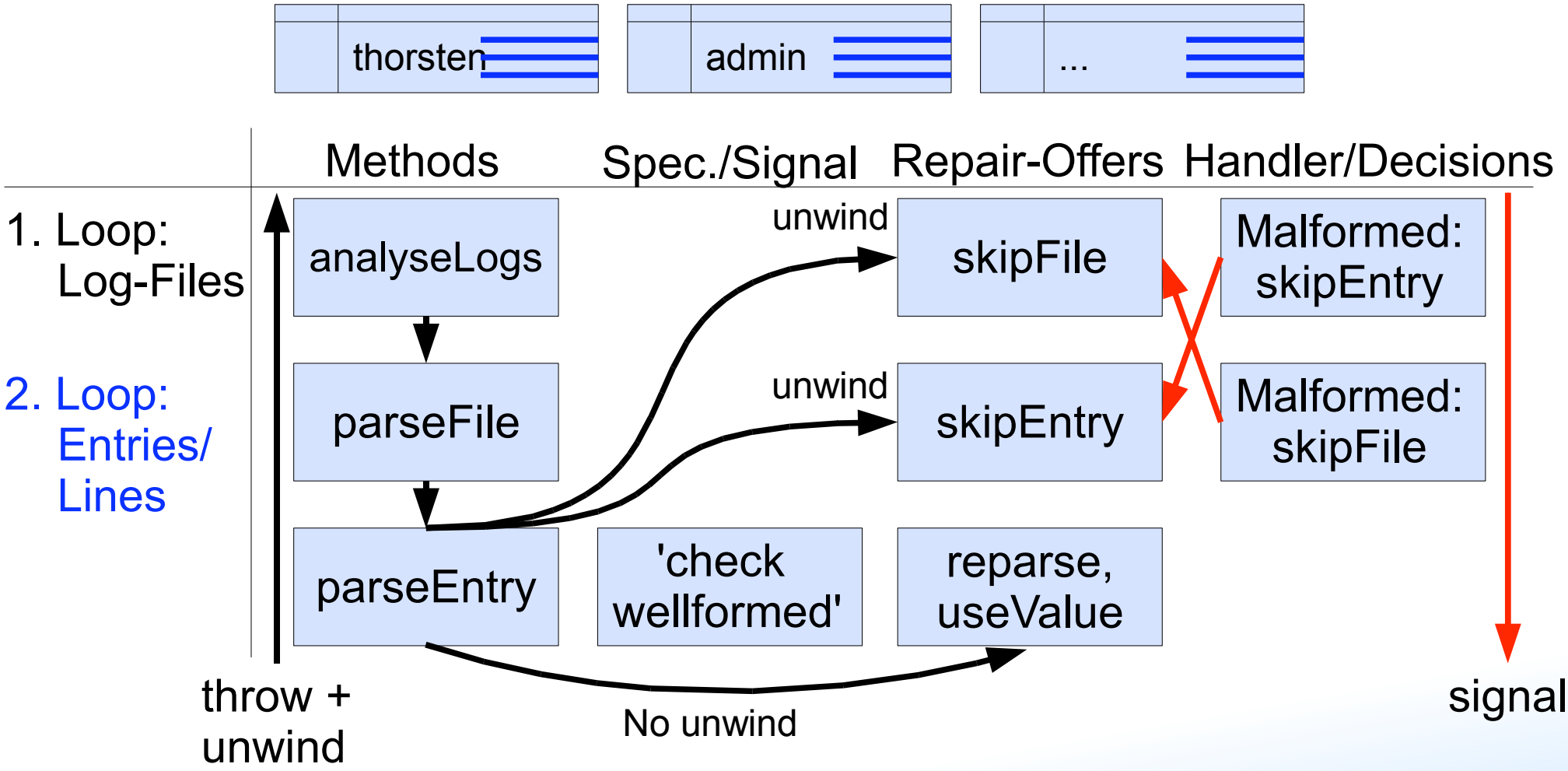
```
public void print(Object document, int fromPage) {
      try {
         // print ...
      } catch (PaperJamDetected jamDetected) {
         // Default problem handling: cancel and logging
         logger.error("Paper jam occured: aborting print.");
      }
}
public void printAdvanced (Object document, int fromPage) {
      try {
         print(document, fromPage);
      } catch (PaperJamDetected jamDetected) {
         // Advanced problem handling: automatically repair
         advancedPaperEmitter.removeJam();
         printAdvanced(document, jamDetected.atPage());
      }
}
```

Not possible!

- Handling can never be overridden, neither for third party nor for own code!

Example for 3-fold separation: read log-files



Lower do not catch anything away from higher
higher can change lower
(“Polymorphism” along the stack)

Example: Idea partly Peter Seibel, Practical Common LISP http://www.gigamonkeys.com/book/beyond-exception-handling-conditions-and-restarts.html

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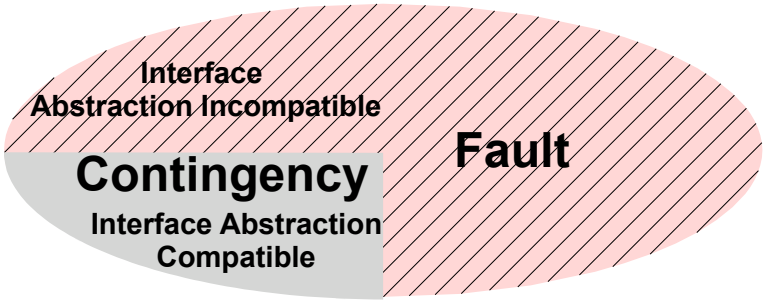
Related Work

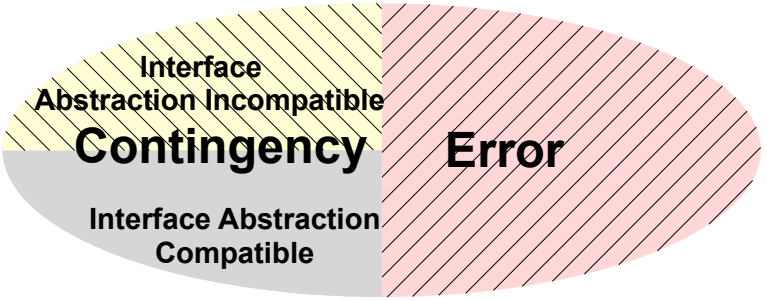
Ruzek's Contingencies [Ruzek07]

„expressed in terms of intended purpose not in terms of implementation“



Our Contingencies

„work refusals, defined conditions, regardless of level“



Domain Partition [Cristian95]:
Relation of results to its prediction by the specification for the input

Standard Domain	Anticipated Exception Domain
Failure Domain	Unanticipated Domain („Specification Failure“)

Related Languages and Mechanisms

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Indispensable features:

1. Ascertain and interactively choose (exists nowhere, yet)
2. Dynamic search top-down (exists nowhere, yet)
3. Resumption at arbitrary level
4. Repair of afflicted implementation details
5. Multiple „offer“ at the same level
6. Exception Safety

At:	Supported:					
	1.	2.	3.	4.	5.	6.
Extended Exception Mechanisms	X	X	X	X	X	
Common Lisp [Pitman90]:			X	X	X	
Smalltalk [Meyer88]:				X		
Closures:				X	X	
Callbacks [Gruler05]:					X	

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Future Work

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- Formalization: set based, similar to [Cristian95]
- Open Source Implementation for Java: extension of
  - Syntax
  - Compiler
  - Standard lib
- Participants are welcome!
- Empirical research with student software practical to explore
- Proposal for the Java Standard (JSR):
  - Expert group according to JCP
  - Extension of Specification
  - Extension of Test suite
- Participants are welcome!

Summary

- Treat contingencies systematically
- New recommendations required
  - Don't declare implementation details, use exceptions
  - Don't abstract and treat specifically
- Extended mechanisms required (3-fold separation)
  - Ascertain interactively at development time
  - Don't unwind immediately
  - Repair and continue
  - Override inappropriate handling
- New mechanisms maybe be of great help for safety critical applications

References

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