

Software Fault Diagnosis for Grid Middleware with Bayesian Networks

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The problem of software diagnosis

- **Not every software fault is a software defect:**
 - Missing runtime resources
 - Misconfiguration
 - Misuse
 - Missing understanding
- **Consequence: software misbehaves, for example**
 - Error messages
 - Performance degradation
 - Unavailability
- **How can we find out *why* software misbehaves?**
- **Interpret**
 - what we can **see** to
 - find out what we can **do** about it?

Why can't software just tell us what is wrong?

- **The “cause/effect chasm” [Eisenstadt 1997]**
 - Separation of faults and their symptoms through *time, space and semantic distance*
- **While **error detection** can and should be implemented in individual software components...**
- **...**fault diagnosis** is a system-level issue:**
 - Openness of systems
 - Desire for reuse and flexibility
 - “Leaky” abstractions [Spolsky 2002]
 - Different use contexts

Fault diagnosis on the Grid

- **Heterogenous runtime environments**
- **Heterogenous user communities**
- **Relatively immature technology**
 - Insufficient documentation
 - Usability problems
 - Layers of leaky abstractions

*Grid components that provide high-level abstractions
when working do expose all gory details when broken.
[Medeiros 2003]*

In a large, open software system...

Don't try to make your error messages make sense.
(You will fail.)

Instead,

Help people make sense of your error messages.

Deductive reasoning

- **If proposition A is true, then B is true.**

$$\begin{array}{r} A \Rightarrow B \\ A \\ \hline B \end{array}$$

- **If proposition B is false, then A is false.**

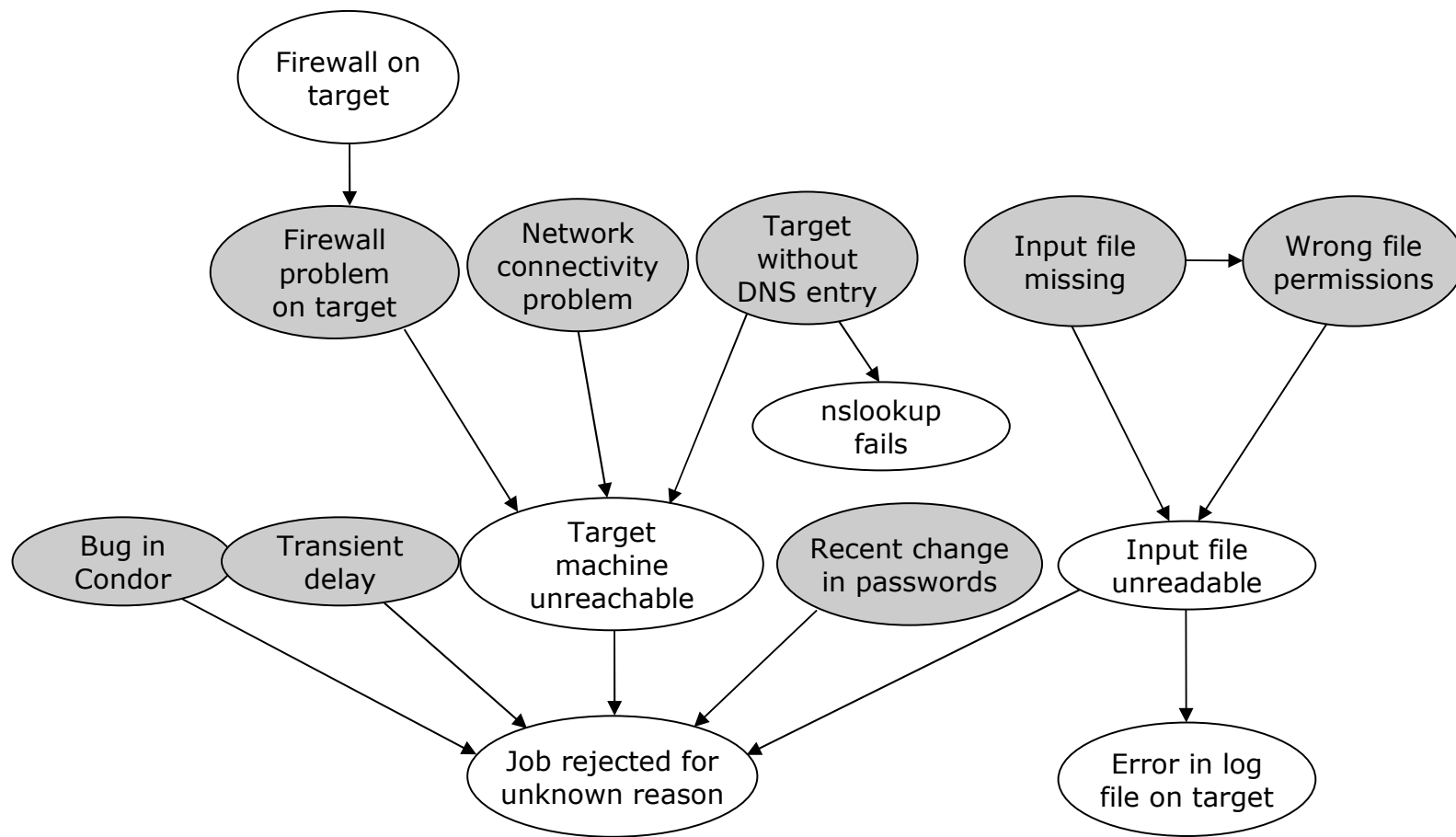
$$\begin{array}{r} A \Rightarrow B \\ \neg B \\ \hline \neg A \end{array}$$

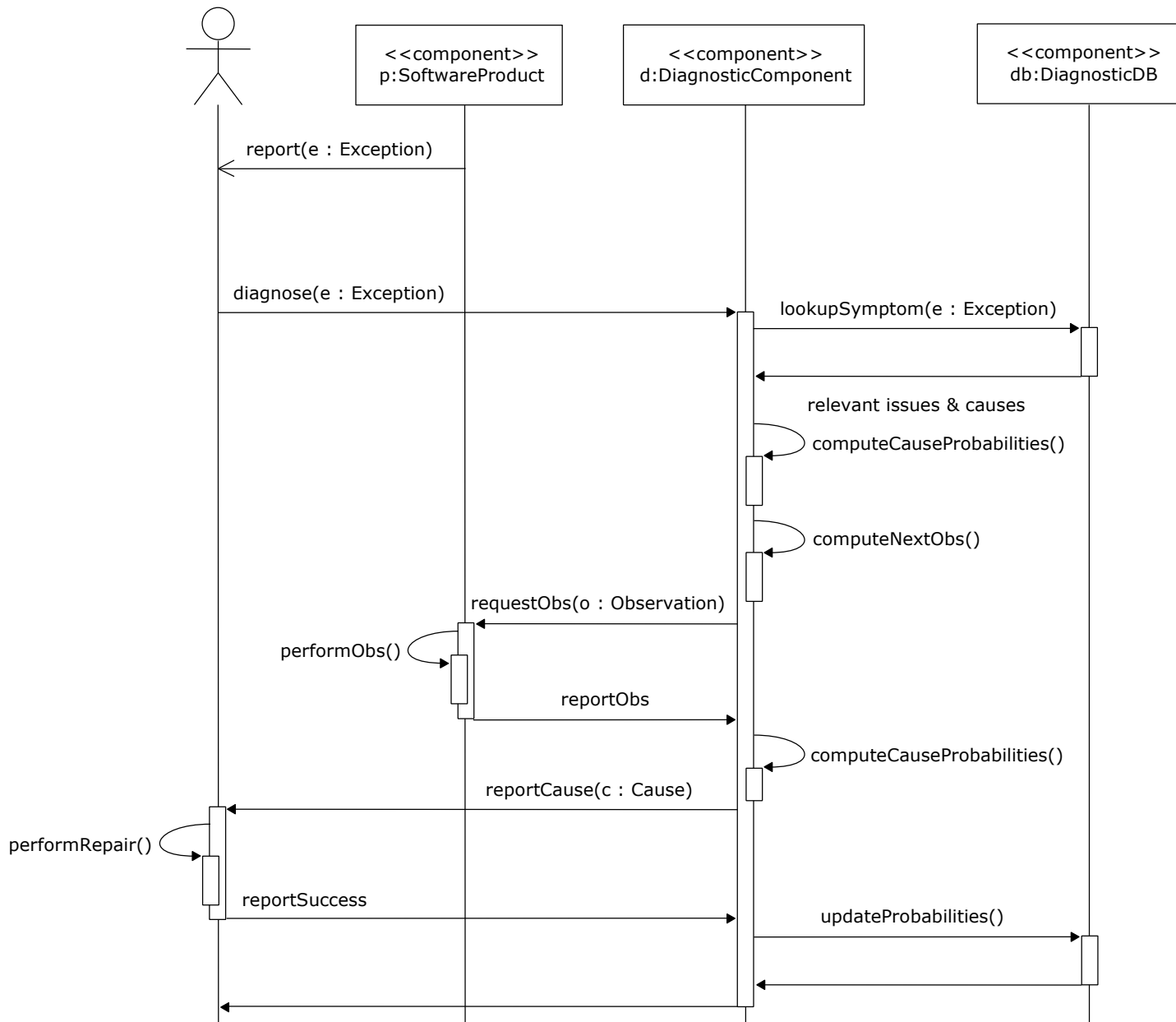
- **Not applicable under uncertainty!**

Inductive reasoning

- **If A is true, B is more likely to be true.**
- **If A is more likely to be true, B is more likely to be true.**
- **Different interpretations of probability**
 - as a (limiting) frequency in a series of random experiments
 - as a measure of reasoner's uncertainty and perceived relationships among a set of propositions
- **Problem: inconsistent probability assignments, e.g.**
$$P(A) + P(\neg A) \neq 1$$
- **Solution: Bayesian Networks**

Modelling of faults and symptoms with BN





Conclusions

- **Software troubleshooting is more than debugging**
 - repeated fault activations are common
 - but for administrators/users, fault activations appear unique
- **Potential for reuse of diagnostic knowledge**
 - bridge the cause/effect chasm using explicit models
 - make models suitable for (semi-)automatic evaluation
 - support online collection of qualitative and quantitative data about faults and their symptoms
- **Challenges**
 - knowledge representation
 - user interface
 - consistency with modelled software