RECOVERY-ORIENTED COMPUTING

Why do Internet services fail, and what can be done about it?

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Motivation

- **Internet service availability is important**
  - email, instant messenger, web search, e-commerce, …
- **User-visible failures are relatively frequent**
  - especially if use non-binary definition of "failure"
- **To improve availability, must know what causes failures**
  - know where to focus research
  - objectively gauge potential benefit of techniques
- **Approach: study failures from real Internet svcs.**
  - evaluation includes impact of humans & networks

Outline

- **Describe methodology and services studied**
- **Identify most significant failure root causes**
  - **source**: type of component
  - **impact**: number of incidents, contribution to TTR
- **Evaluate HA techniques to see which of them would mitigate the observed failures**
- **Drill down on one cause: operator error**
- **Future directions for studying failure data**

Methodology

- **Obtain "failure" data from three Internet services**
  - two services: problem tracking database
  - one service: post-mortems of user-visible failures

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  - type of failure
    - » "component failure" *vs.* "service failure"
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  - time to diagnose + repair (TTR)
- **Did not look at security problems**

Comparing the three services

characteristic	*Online*	*ReadMostly*	*Content*
hits per day	~100 million	~100 million	~7 million
# of machines	~500 @ 2 sites	> 2000 @ 4 sites	~500 @ ~15 sites
front-end node architecture	custom s/w; Solaris on SPARC, x86	custom s/w; open-source OS on x86	custom s/w; open-source OS on x86;
back-end node architecture	Network Appliance filers	custom s/w; open-source OS on x86	custom s/w; open-source OS on x86
period studied	7 months	6 months	3 months
# component failures	296	N/A	205
# service failures	40	21	56

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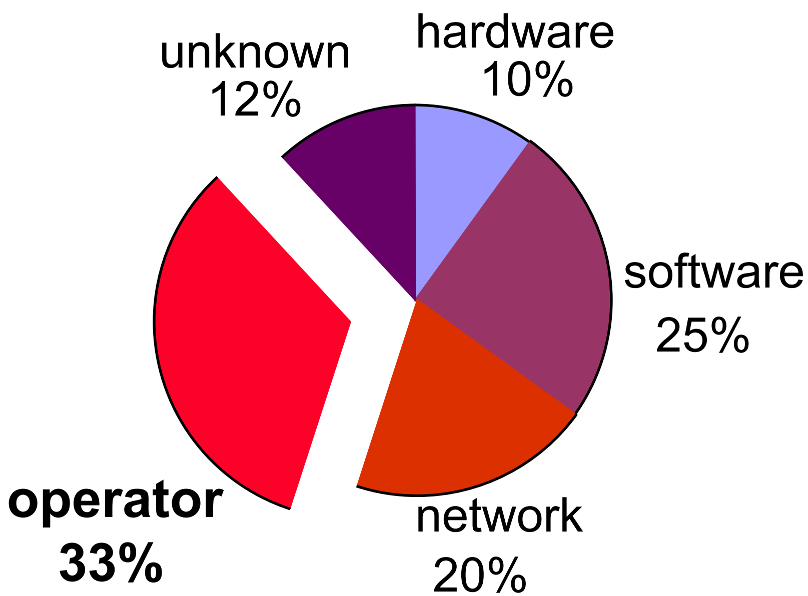
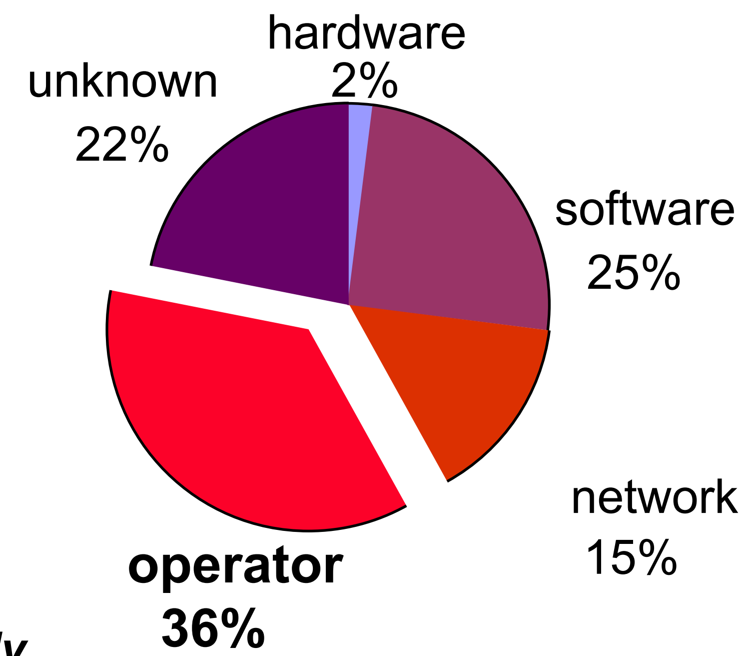
Failure cause by % of service failures

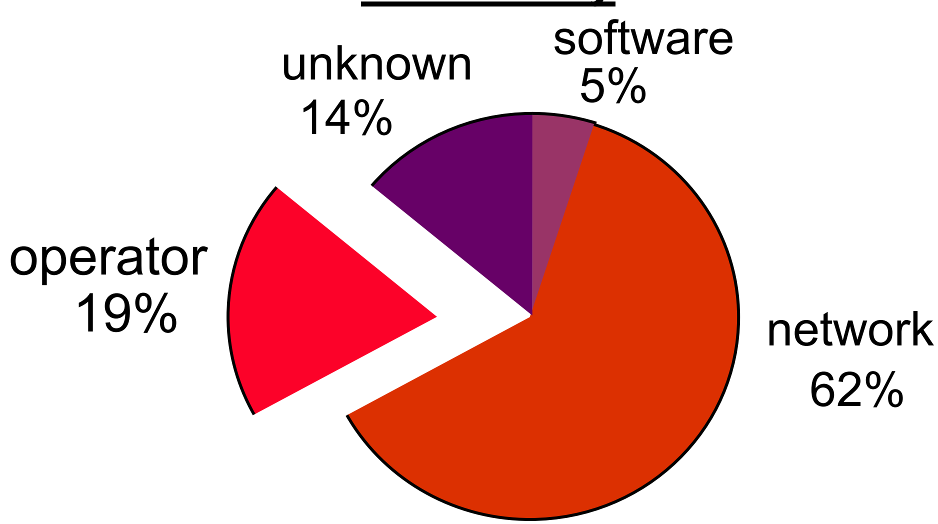
Online



Content

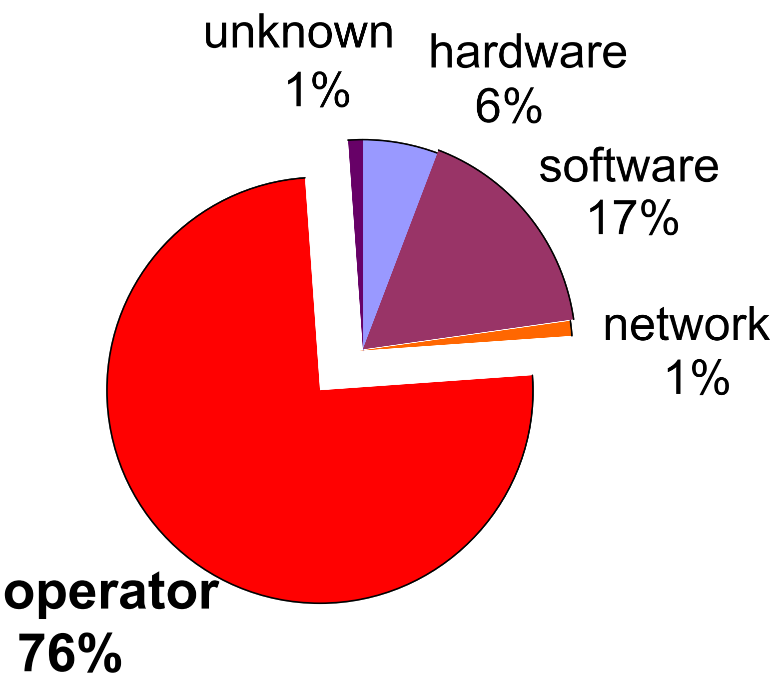


ReadMostly



Failure cause by % of TTR

Online



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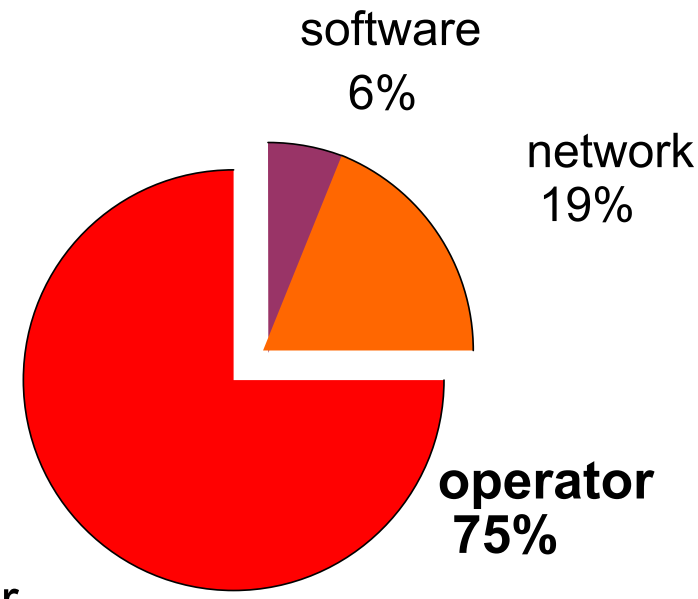
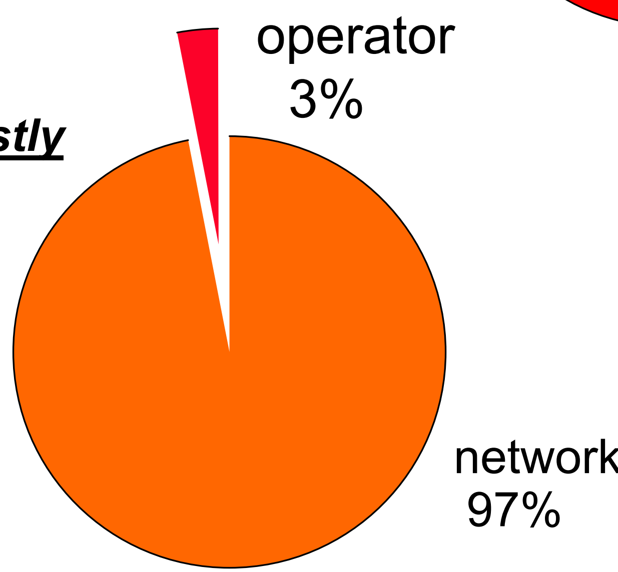


ReadMostly



Most important failure root cause?

- **Operator error generally the largest cause of service failure**
  - even more significant as fraction of total "downtime"
  - configuration errors > 50% of operator errors
  - generally happened when making changes, not repairs
- **Network problems significant cause of failures**

Related work: failure causes

- **Tandem systems** (Gray)
  - 1985: **Operator 42%,** software 25%, hardware 18%
  - 1989: Operator 15%, software 55%, hardware 14%
- **VAX** (Murphy)
  - 1993: **Operator 50%,** software 20%, hardware 10%
- **Public Telephone Network** (Kuhn, Enriquez)
  - 1997: **Operator 50%,** software 14%, hardware 19%
  - 2002: **Operator 54%,** software 7%, hardware 30%

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Potential effectiveness of techniques?

technique
post-deployment correctness testing*
expose/monitor failures*
redundancy*
automatic configuration checking
post-deploy. fault injection/load testing
component isolation*
pre-deployment fault injection/load test
proactive restart*
pre-deployment correctness testing*

* *indicates technique already used by* Online

Potential effectiveness of techniques?

technique	failures avoided / mitigated
post-deployment correctness testing*	26
expose/monitor failures*	12
redundancy*	9
automatic configuration checking	9
post-deploy. fault injection/load testing	6
component isolation*	5
pre-deployment fault injection/load test	3
proactive restart*	3
pre-deployment correctness testing*	2

(40 service failures examined)

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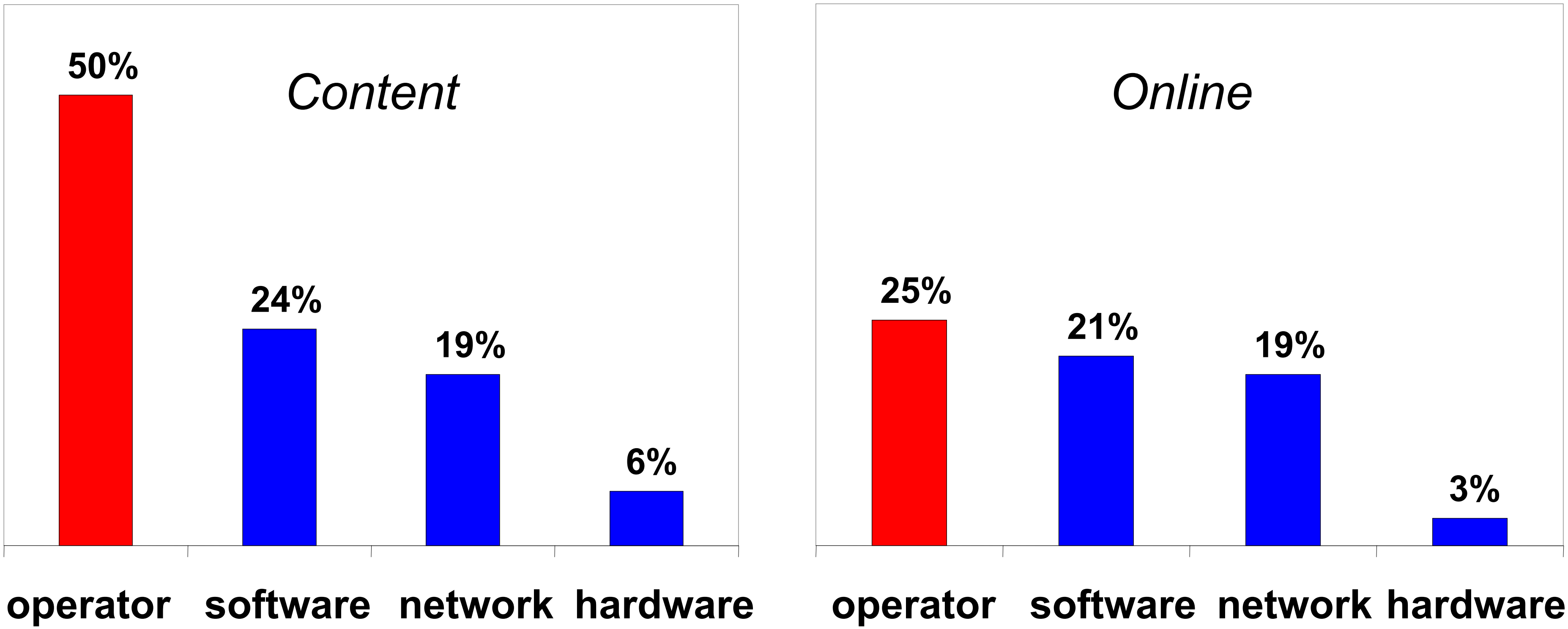
Drilling down: operator error

Why does operator error cause so many svc. failures?

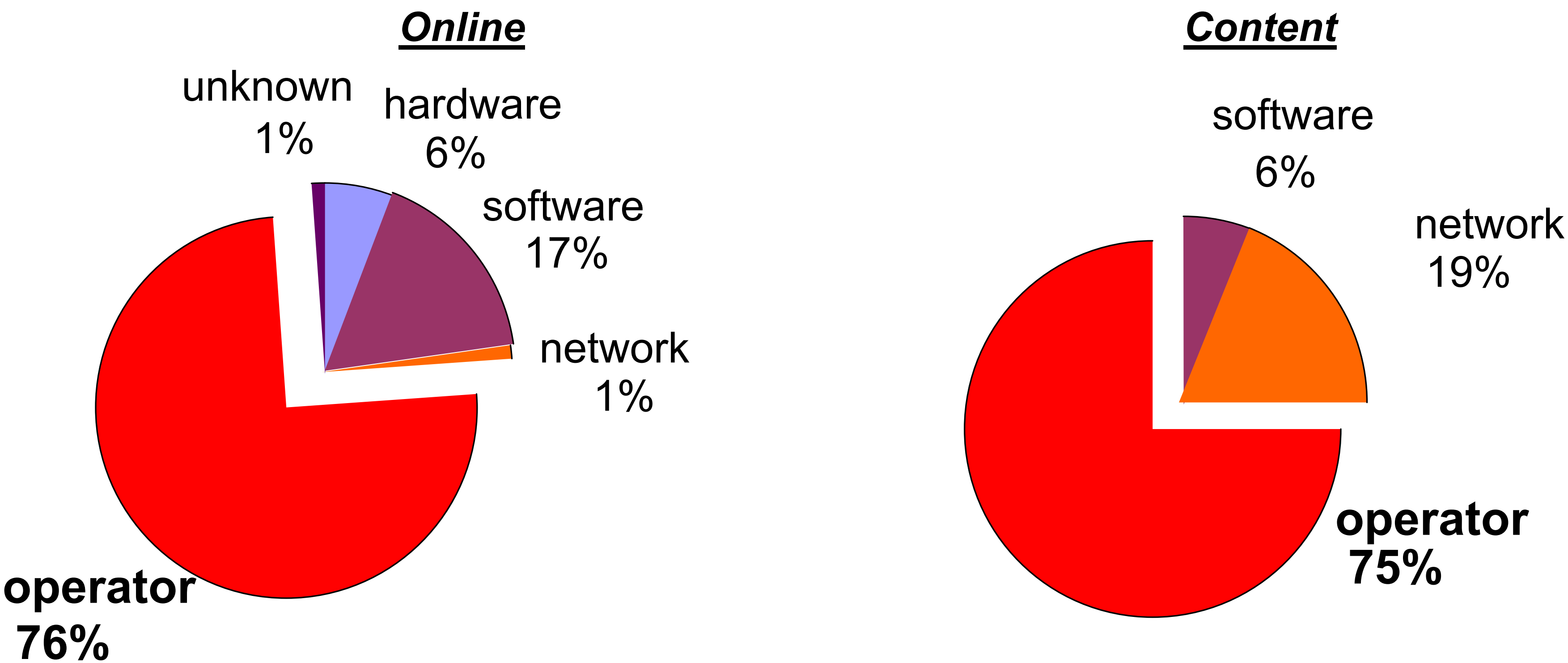
% of component failures resulting in service failures



Existing techniques (*e.g.*, redundancy) are minimally effective at masking operator error

Drilling down: operator error TTR

Why does operator error contribute so much to TTR?



Detection and diagnosis difficult because of non-failstop failures and poor error checking

Future directions in studying failures

- **Quantify impact of of operational practices**
- **Study additional types of sites**
  - transactional, intranets, peer-to-peer
- **Create a public failure data repository**
  - standard taxonomy of failure causes
  - standard metrics for impact
  - techniques for automatic anonymization
  - security (not just reliability)
  - automatic analysis (mining for trends, fixes, attacks, …)
- **Perform controlled laboratory experiments**

Conclusion

- **Operator error large cause of failures, downtime**
- **Many failures could be mitigated with**
  - better post-deployment testing
  - automatic configuration checking
  - better error detection and diagnosis
- **Longer-term: concern for operators must be built into systems from the ground up**
  - make systems robust to operator error
  - reduce time it takes operators to detect, diagnose, and repair problems

Willing to contribute failure data, or information about problem detection/diagnosis techniques?

http://roc.cs.berkeley.edu/projects/faultmanage/

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