Growing a Protocol

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Motivation

- ✦ Elastic - distributed data store vendor whose products focus on real time search and analysis

- ✦ Data replication protocol is based on Primary/Backup

- ✦ Interested in a tool to determine if protocol was behaving correctly in the presence of faults as it evolves

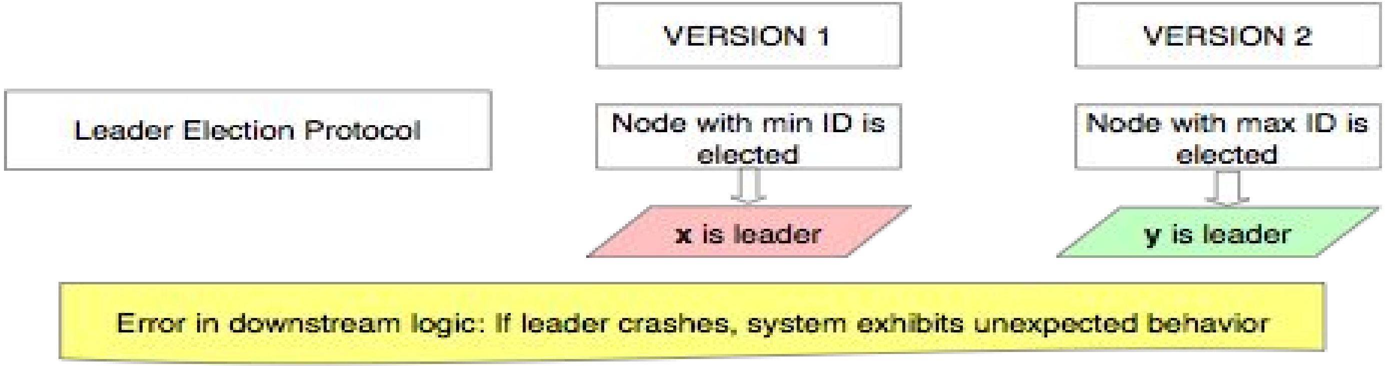
Introduction

- Software engineering best practices:
  - Regression testing
  - Root cause analysis

- Does not work while reasoning about fault tolerance properties of distributed systems

- Associate *specific inputs* with *system behaviors*

An example



Leader Election Protocol

VERSION 1

Node with min ID is elected

x is leader

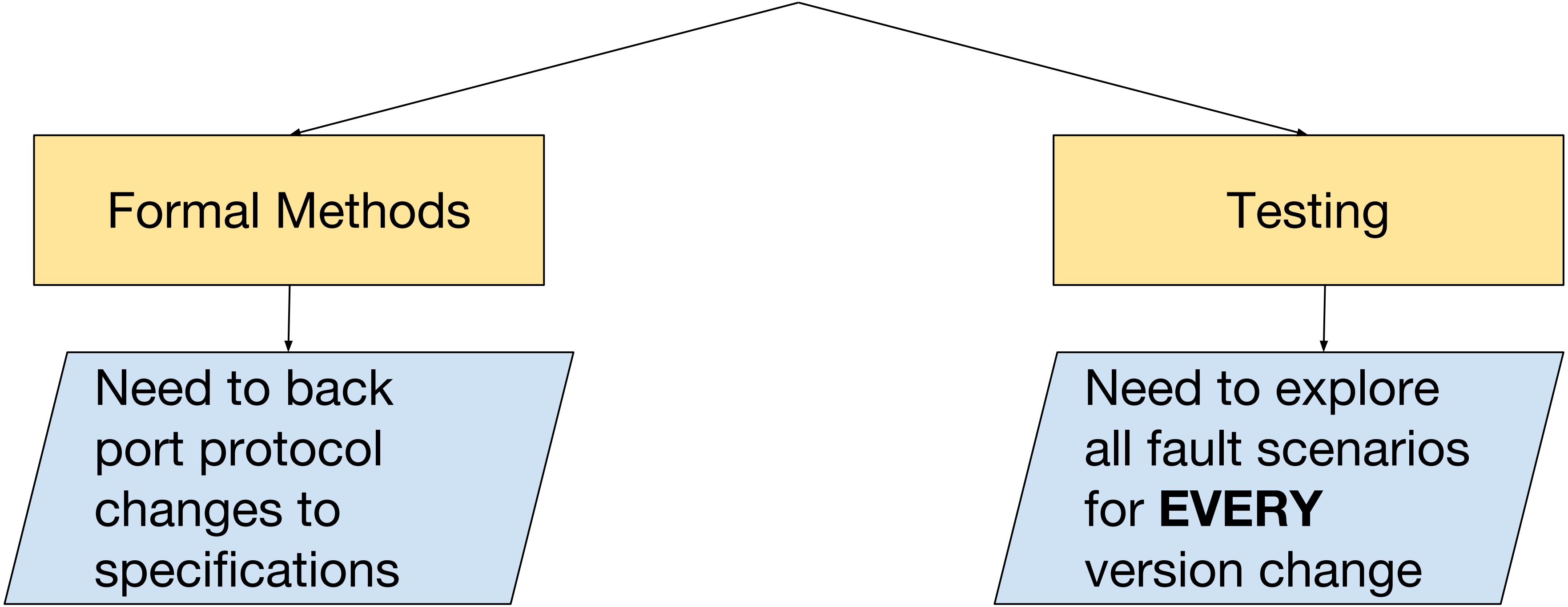
VERSION 2

Node with max ID is elected

y is leader

Error in downstream logic: If leader crashes, system exhibits unexpected behavior

Naive Solution(s)



Formal Methods

Testing

Need to back port protocol changes to specifications

Need to explore all fault scenarios for **EVERY** version change

Lineage Driven Fault Injection

- LDFI - Lineage Driven Fault Injection
  - Uses techniques from databases, logic programming and fault injection techniques

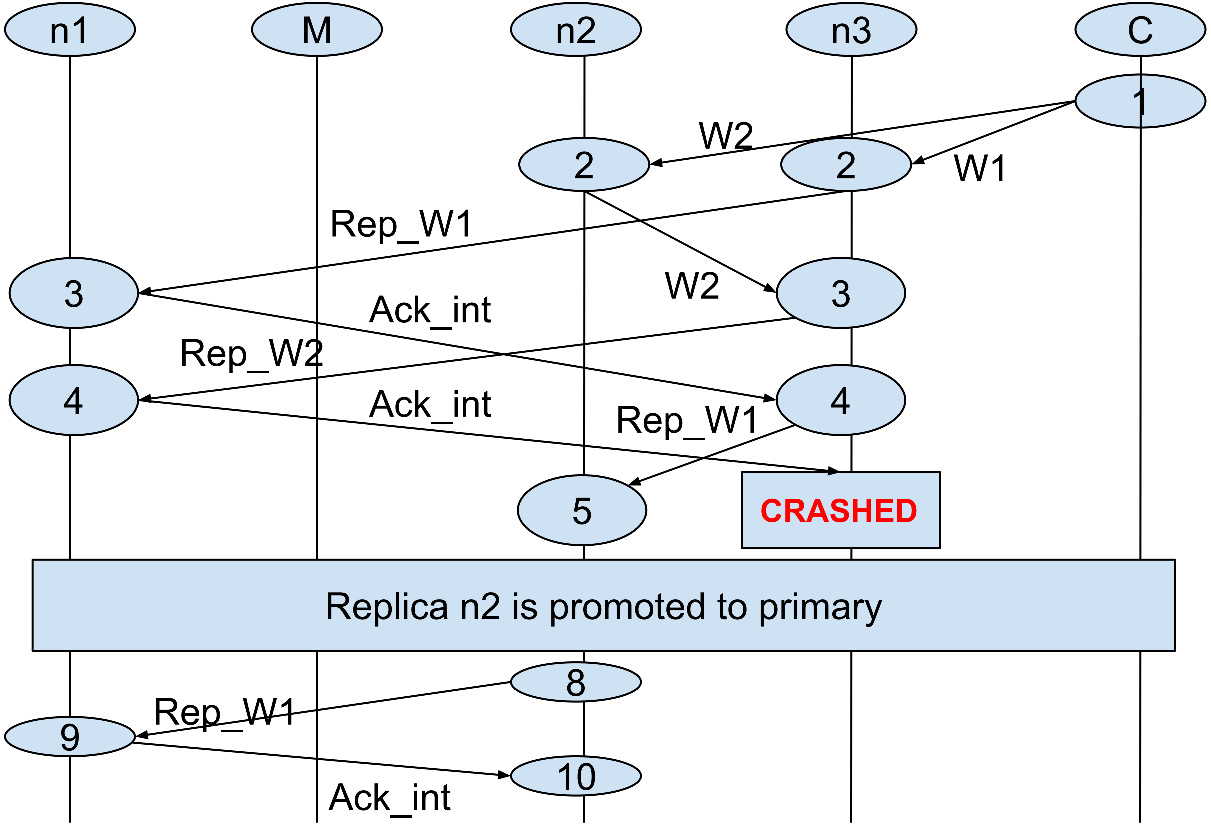
- Reasons about *how* a good outcome occurred to determine *why* a bad outcome *might* occur

Background

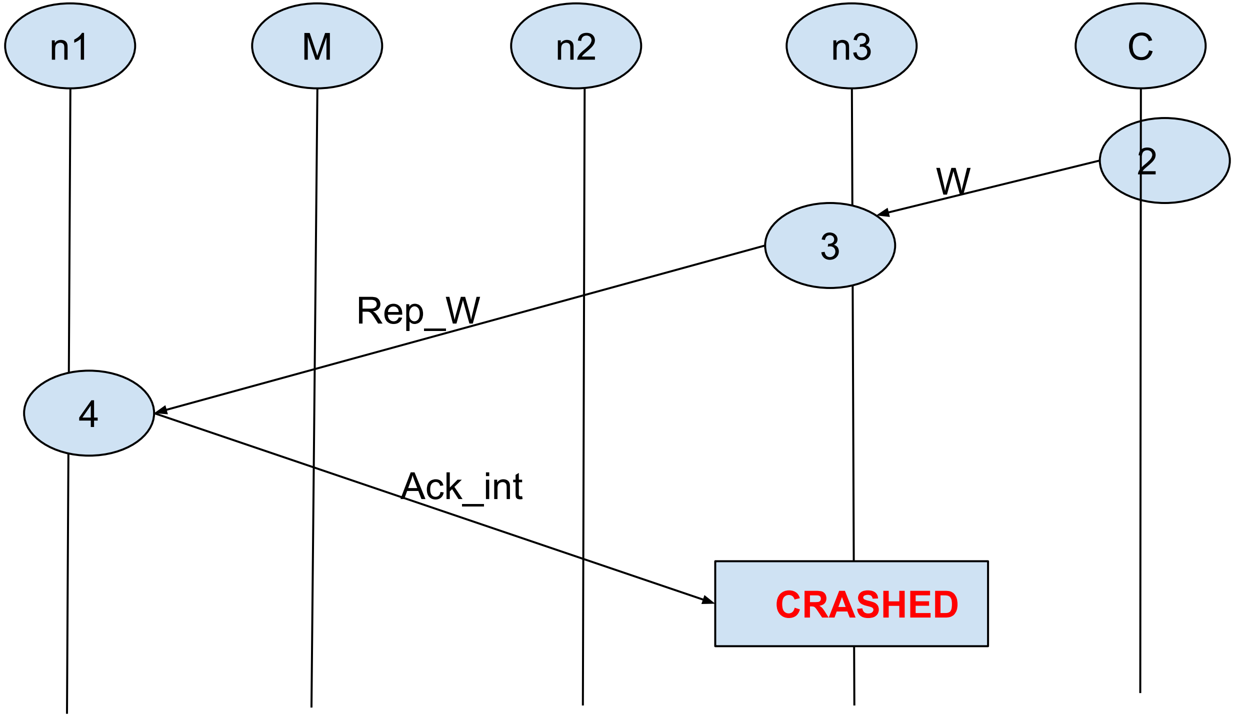
- LDFI builds a system model beginning with the first execution being successful

- Fault scenarios explored are those which falsify good outcome

Catching Bugs early …



Dormant bugs



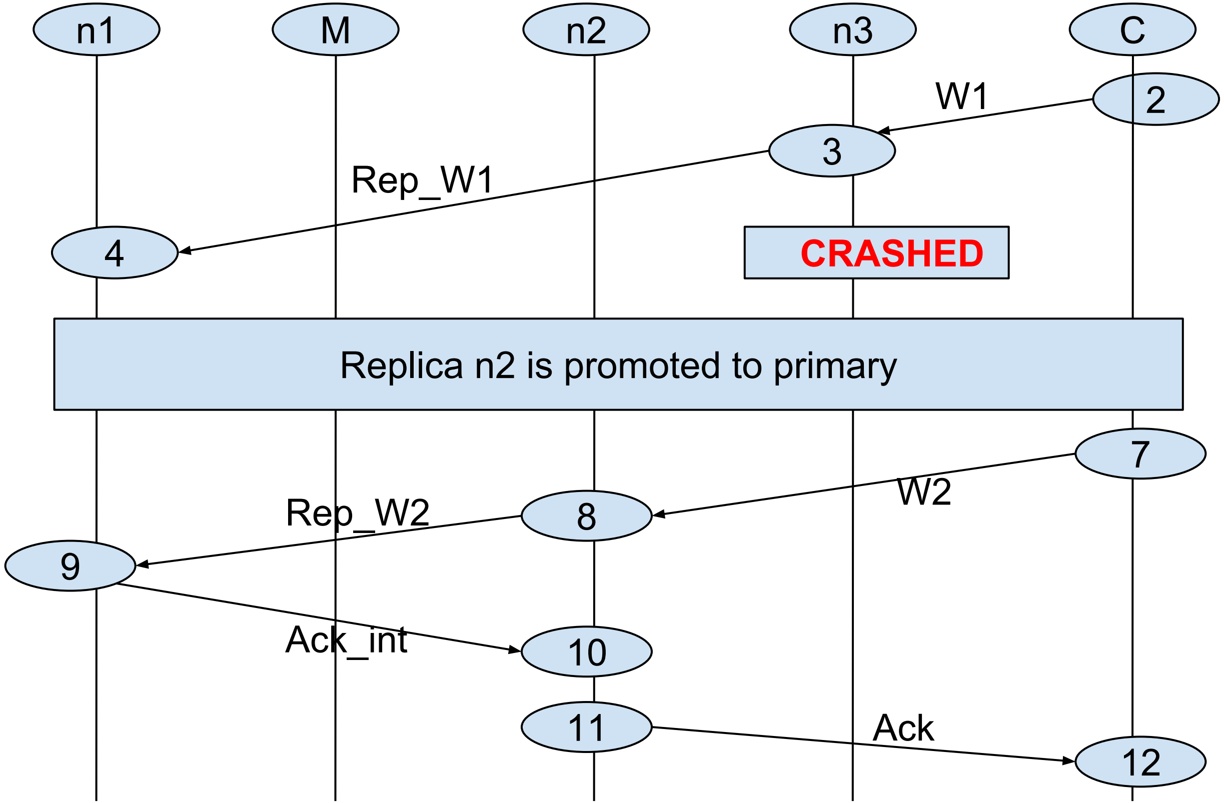
A tale of two optimizations

- Specially handling certain cases to avoid expensive operations

- Re-sync mechanisms

The “simplicity” of an optimization is not a barometer in understanding if it **could** violate guarantees of the system

Avoiding expensive operations

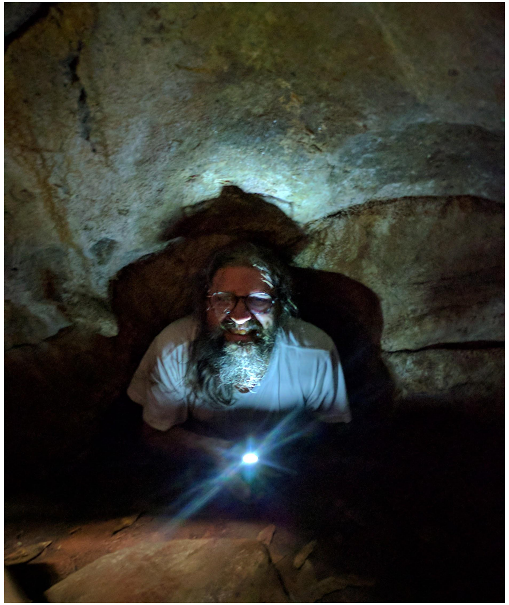


Past & Future Work

- Concurrency bugs
  - Explore not just schedules, but reorderings as well.
- Input Generation
  - Different fault scenarios based on input data selected. Impacts bugs found.

Summary

- Debugging distributed systems is hard!
- Need tools which straddle verification and testing
- Demonstrated that LDFI can be deployed as a tool in this space to find interesting bugs



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Questions ?

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https://github.com/KamalaRamas/molly