Encoded Protocols Overhead Analysis on Elections

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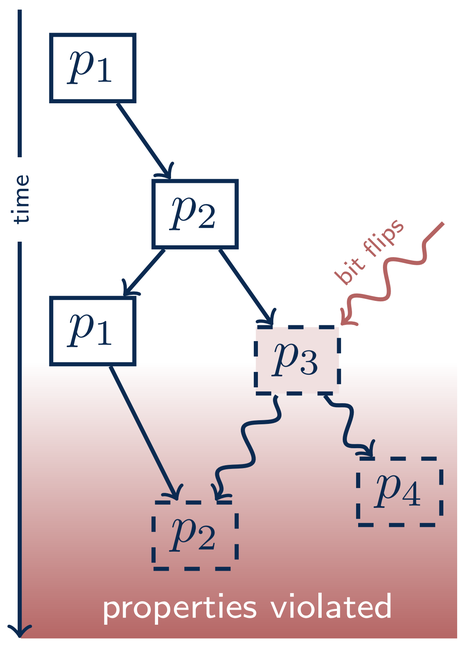
Bit Flips in Distributed Systems

- Distributed systems typically tolerate crash faults
- Arbitrary faults, *e.g.*, bit flips, occur **surprisingly often**
- Can **disrupt large services** such as Amazon S3

Problem:

- **Cope with bit flips**
- **Without expensive Byzantine-fault tolerance**

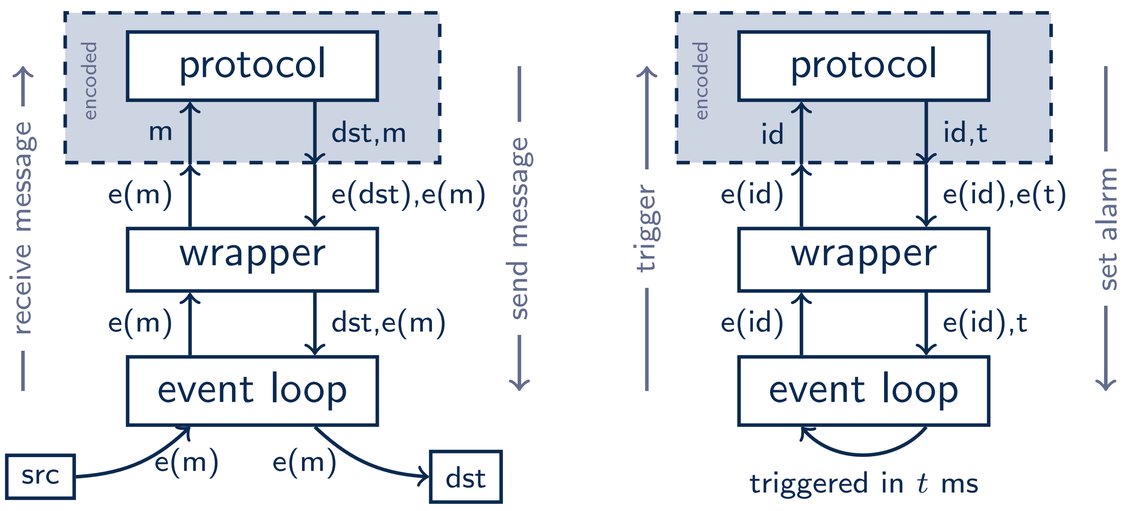


A Framework for Distributed Protocols

- **Automatically improves the fault coverage** of protocols for crash-fault model
- Uses **encoding compiler** by Schiffel *et al.*
- Encoded protocols tolerate **non-malicious arbitrary** faults, *e.g.*, bit flips and hardware design faults

Virtualizing Non-malicious Arbitrary Faults

- Errors within shaded area abort process
- Propagated errors invalidate encoding
- Invalid encoding treated as omission/performance failures



* $e(x)$ means x is encoded.

Open Questions – Future Work

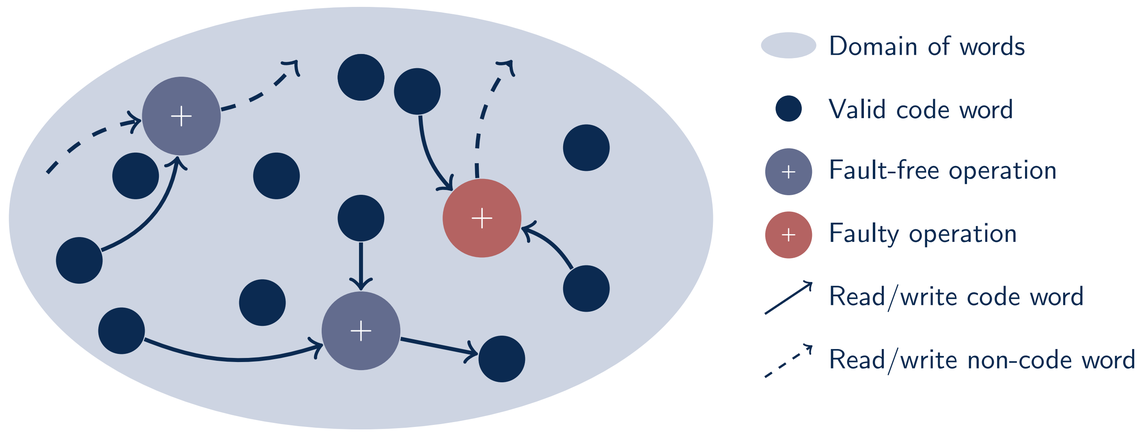
Current work:

- Overhead of encoding **atomic broadcast** protocols
- Stronger encoding: use ANB-encoding
- **Fault injection**: how dangerous are bit flips?

Further research questions:

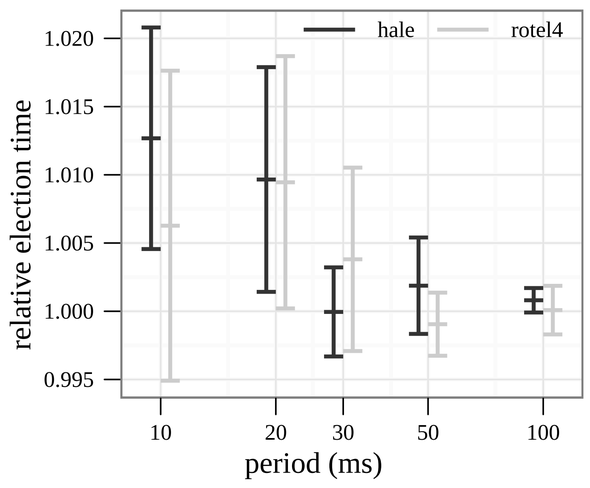
- How to **partially encode** protocols?
  - Theoretical implications (hybrid models)
  - Performance benefits

Encoding in a Nutshell

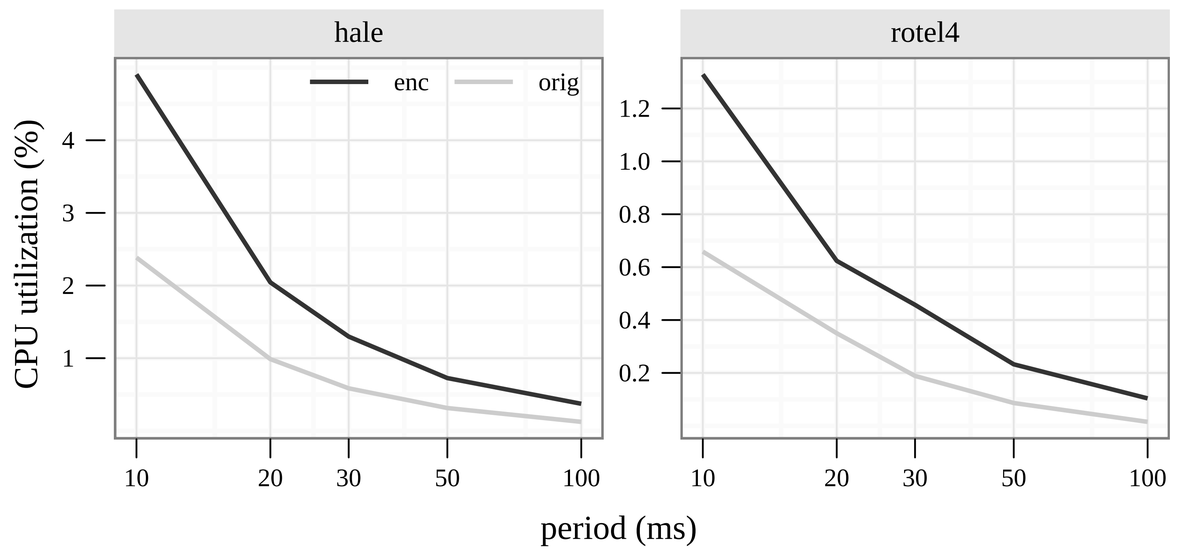


- Each 32-bit value encoded in a 64-bit value
- Domain divided in
  - a few valid values (code words)
  - many invalid values (non-code words)
- All operations transformed to support encoding

Overhead Analysis: AN-encoded Elections



- Election time overhead less than 2%
- Doubled CPU overhead, 10 ms heart-beat period
- Absolute CPU utilization less than 5%
- **Low cost for elections**



Assumptions and Fault Models

- No process identifies itself as another process
- No reverse engineering of encoding
- Non-synchronized local clocks available
- Clocks do not fail

Encoding flavors:

Error	no encoding	AN	ANB	ANBDmem
crash & omission/performance	X	X	X	X
corruption on transmission	X	X	X	X
faulty operation		X	X	X
data corruption		X	X	X
control flow			X	X
address bus on read			X	X
address bus on write				X

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