Paxos: A Greek Island

First: A Note About Final Project Proposals

- Computers - you can make them do nearly anything or at least simulate many realities

- Mostly what you have been doing in the labs: implement algorithm, check if it behaves as described/expected

- Science ("natural science")

  Observe some phenomenon \(\Rightarrow\) hypothesis on why/what it means \(\Rightarrow\) experiments to check

- Computer science (maybe just systems)
Hypothesis Dictates Experiment

Example: PBS to Evaluate Consistency of Dynamo

- Consistency observed depends on many factors.
- Hard to see what you are trying to show or do if you don’t discuss or enumerate factors.

Also hard for you to set up tests or draw conclusions.

Back to Scheduled Programming

- Replicated state machines
RSM Protocol Decomposition

- Command Replication
  - AE

- Sequencing
  - LDR

- Command Replication
  → Send to other processes
  → Decide when safe to deliver

- Sequencing
  → Decide what you send. A command M decides

How
- M sends, others add
- M counts
RSM Protocol Decomposition

Leader Election Protocols

Agreement Protocol

Observation: Both need to deal with multiple processes simultaneously invoking a protocol. Why?

Consequence: Agreement protocol must be correct even if two processes believe they are leader.

Q: How is this done in Raft?
Designing Agreement Protocol Without Assuming Anything About Leaders

Requirements
1. Only One Winner
2. Winner knows they won (Why?)

Synod Protocol

\[
\begin{align*}
&\text{PROPOSE}(n) \\
&\text{.Promise}(n) \\
&\text{Promise}(n, m, v)
\end{align*}
\]
1. \( n \in \mathbb{Z}^+ \) (ROUND)

2. \( \text{Promise}(n) : \text{I will never promise or accept something with round } \lt n \)
   
   \( \text{Promise}(n,m,v) : \text{I will... round } \lt n \). Also, previously in round \( m \) I accepted \( v \).

3. Got Promises from quorum.
   
   \( \triangleright \) If one or more \( \text{Promise}(n,m,v) \) messages received then \( W = v \_m \) for largest \( m \).

4. Did not make new promise.

- Deliver after accepted messages from quorum.
Questions

1. Why Promise \((n, m, v)\)?

2. How to extend this to multiple slots?
Propose ($C_{lot, n}$)

ACCE

3. What have we lost from RAFT?

Why?
- Log completeness

RAFT

Leader has no auth-log

SYNOD

Proposal accepted
- Can we avoid the extra steps when using Synod?

**Diagrams:**

- Slots
- **TERM**
- **PROPOSE (0..n)**
- Multi-Paxos
- Synod
- Decoupled, first 10 1970
Some Way To Elect Leaders
+ Optimization

Is This Really Worthwhile?

- Beefier Leaders

- Mencius

Wide-Area Consensus
Compartmentalized Paxos \rightarrow Improve Throughput
RSM/Consensus In Practice

Paxos, Raft, ZAB, Chubby/ETCD/ZooKeeper/...

- Key Value Store/FileSystem Interface
o Locks + Leases

mul

PROPPOSE(55, 2) → PROMISE(55, 2)

mul

PROPPOSE(55, 3)