

# The Part-Time Parliament

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# The Part-Time Parliament

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Recent archaeological discoveries on the island of Paxos reveal that the parliament functioned despite the peripatetic propensity of its part-time legislators. The legislators maintained consistent copies of the parliamentary record, despite their frequent forays from the chamber and the forgetfulness of their messengers. The Paxos parliament's protocol provides a new way of implementing the state-machine approach to the design of distributed systems.

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This submission was recently discovered behind a filing cabinet in the *TOCS* editorial office. Despite its age, the editor-in-chief felt that it was worth publishing. Because the author is currently doing field work in the Greek isles and cannot be reached, I was asked to prepare it for publication.

The author appears to be an archeologist with only a passing interest in computer science. This is unfortunate; even though the obscure ancient Paxos civilization he describes is of little interest to most computer scientists, its legislative system is an excellent model for how to implement a distributed computer system in an asynchronous environment. Indeed, some of the refinements the Paxos made to their protocol appear to be unknown in the systems literature.

The author does give a brief discussion of the Paxos Parliament's relevance to distributed computing in Section 4. Computer scientists will probably want to read that section first. Even before that, they might want to read the explanation of the algorithm for computer scientists by Lamport [1996]. The algorithm is also described more formally by De Prisco et al. [1997]. I have added further comments on the relation between the ancient protocols and more recent work at the end of Section 4.

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## 1 The Problem

### 1.1 The Island of Paxos

Early in this millennium, the Aegean island of Paxos was a thriving mercantile center.<sup>1</sup> Wealth led to political sophistication, and the Paxons replaced their ancient theocracy with a parliamentary form of government. But trade came before civic duty, and no one in Paxos was willing to devote his life to Parliament. The Paxon Parliament had to function even though legislators continually wandered in and out of the parliamentary Chamber.

The problem of governing with a part-time parliament bears a remarkable correspondence to the problem faced by today's fault-tolerant distributed systems, where legislators correspond to processes and leaving the Chamber corresponds to failing. The Paxons' solution may therefore be of some interest to computer scientists. I present here a short history of the Paxos Parliament's protocol, followed by an even shorter discussion of its relevance for distributed systems.

Paxon civilization was destroyed by a foreign invasion, and archeologists have just recently begun to unearth its history. Our knowledge of the Paxon Parliament is therefore fragmentary. Although the basic protocols are known, we are ignorant of many details. Where such details are of interest, I will take the liberty of speculating on what the Paxons might have done.

### 1.2 Requirements

Parliament's primary task was to determine the law of the land, which was defined by the sequence of decrees it passed. A modern parliament will employ a secretary to record its actions, but no one in Paxos was willing to remain in the Chamber throughout the session to act as secretary. Instead, each Paxon legislator maintained a *ledger* in which he recorded the numbered sequence of decrees that were passed. For example, legislator  $\Lambda\nu\chi\partial$ 's ledger had the entry

155: *The olive tax is 3 drachmas per ton*

if she believed that the 155<sup>th</sup> decree passed by Parliament set the tax on olives to 3 drachmas per ton. Ledgers were written with indelible ink, and their entries could not be changed.

The first requirement of the parliamentary protocol was the *consistency of ledgers*, meaning that no two ledgers could contain contradictory information. If legislator  $\Phi\iota\sigma\partial\epsilon\rho$  had the entry

132: *Lamps must use only olive oil*

in his ledger, then no other legislator's ledger could have a different entry for decree 132. However, another legislator might have no entry in his ledger for decree 132 if he hadn't yet learned that the decree had been passed.

Consistency of ledgers was not sufficient, since it could be trivially fulfilled by leaving all ledgers blank. Some requirement was needed to guarantee that decrees

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<sup>1</sup>It should not be confused with the Ionian island of Paxoi, whose name is sometimes corrupted to *Paxos*.