

# Introduction

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- Network Time Protocol (NTP) synchronizes clocks of hosts and routers in the Internet
- Well over 100,000 NTP peers deployed in the Internet and its tributaries all over the world
- Provides nominal accuracies of low tens of milliseconds on WANs, submilliseconds on LANs, and submicroseconds using a precision time source such as a cesium oscillator or GPS receiver
- Unix NTP daemon ported to almost every workstation and server platform available today - from PCs to Crays - Unix, Windows, VMS and embedded systems



## Needs for synchronized time

- Distributed database journal and transaction ordering
- Stock market buy and sell orders
- Cryptographic timestamping services
- Intrusion detection, isolation and logging
- Network monitoring, measurement and control
- Distributed multimedia stream synchronization
- RPC at-most-once transactions; replay defenses; sequence-number disambiguation
- Research experiment setup, measurement and control
- Cryptographic key management and lifetime control

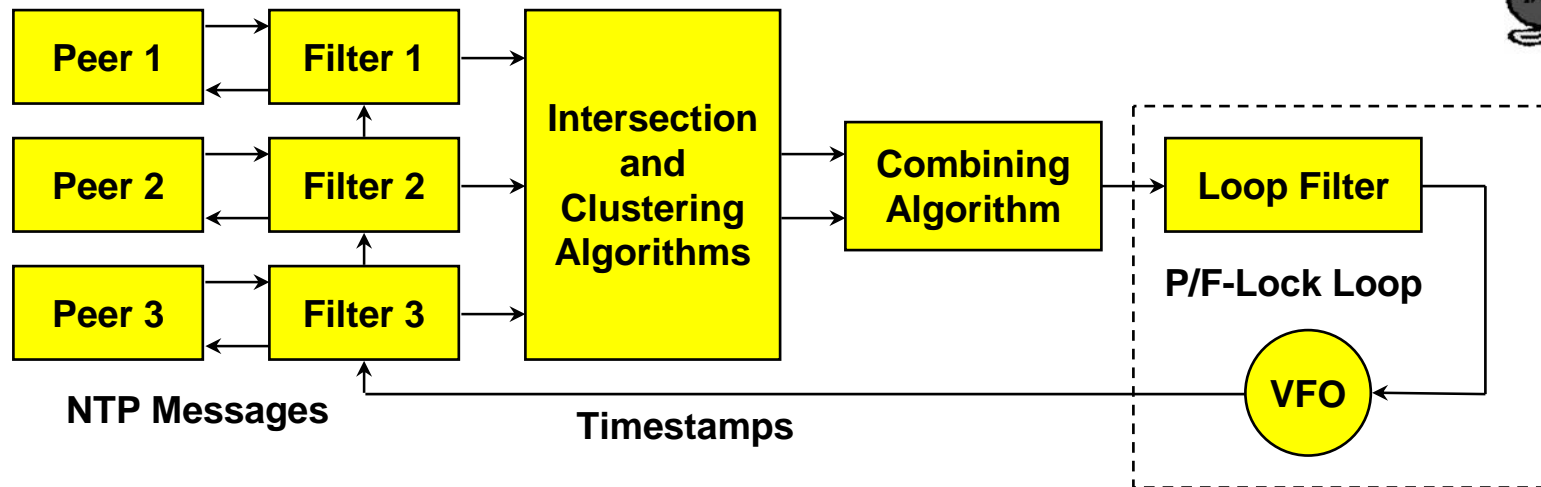


## NTP capsule summary

- Primary (stratum 1) servers synchronize to national time standards via radio, satellite and modem
- Secondary (stratum 2, ...) servers and clients synchronize to primary servers via hierarchical subnet
- Clients and servers operate in master/slave, symmetric or multicast modes with or without cryptographic authentication
- Reliability assured by redundant servers and diverse network paths
- Engineered algorithms reduce jitter, mitigate multiple sources and avoid improperly operating servers
- System clock is disciplined in time and frequency using an adaptive algorithm responsive to network time jitter and clock oscillator frequency wander



## How NTP works

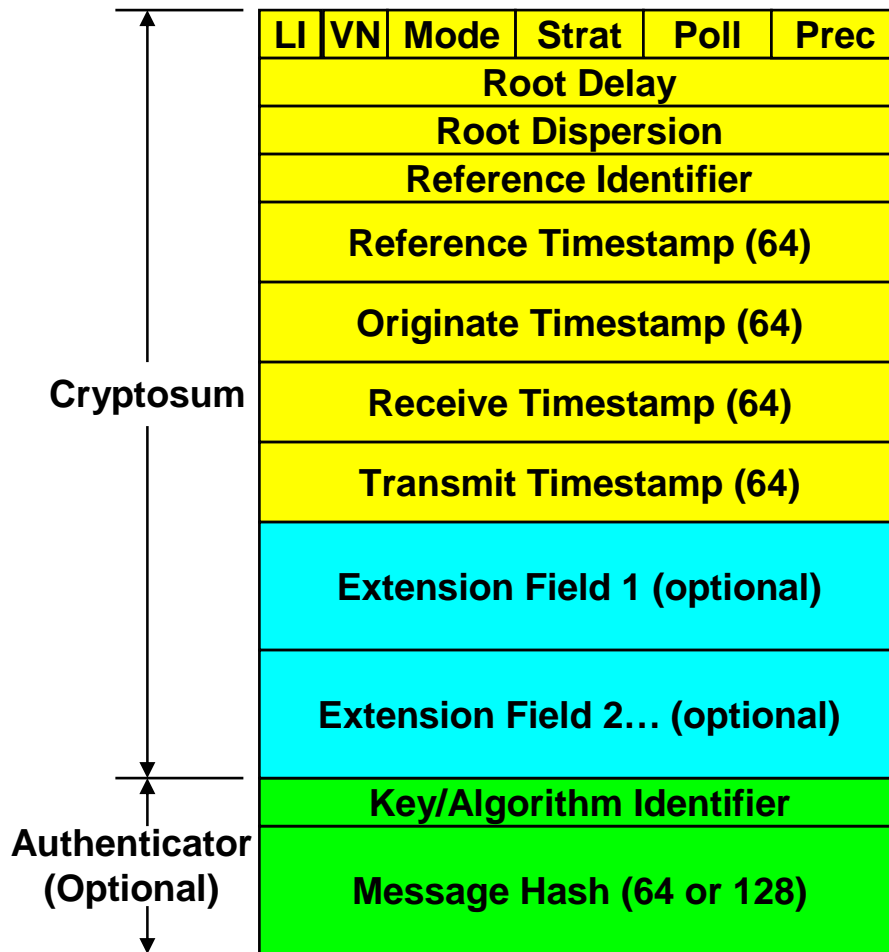


- Multiple synchronization peers provide redundancy and diversity
- Clock filters select best from a window of eight clock offset samples
- Intersection and clustering algorithms pick best subset of servers believed to be accurate and fault-free
- Combining algorithm computes weighted average of offsets for best accuracy
- Phase/frequency-lock feedback loop disciplines local clock time and frequency to maximize accuracy and stability

# NTP protocol header and timestamp formats



NTP Protocol Header Format (32 bits)



- LI      leap warning indicator
- VN      version number (4)
- Strat    stratum (0-15)
- Poll     poll interval (log2)
- Prec     precision (log2)

NTP Timestamp Format (64 bits)

Seconds (32)	Fraction (32)
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Value is in seconds and fraction since 0<sup>h</sup> 1 January 1900

NTPv4 Extension Field

Field Length	Field Type
Extension Field (padded to 32-bit boundary)	

Last field padded to 64-bit boundary

NTP v3 and v4
NTP v4 only
authentication only

Authenticator uses DES-CBC or MD5 cryptosum of NTP header plus extension fields (NTPv4)