

Ethereum Upgrades

The Ethereum network has undergone a series of significant upgrades since its launch, which can be broadly categorized as different stages in its development roadmap. The purpose of these upgrades is generally to improve **security, scalability, efficiency, and sustainability**.

Past Upgrades

- **Frontier (2015):**
 - **Original Launch:** The initial, barebones launch of the Ethereum blockchain, allowing for the mining of Ether (ETH) and the deployment of a prototype decentralized application (Baldauf et al., 2023; Ahn et al., 2024).
- **Homestead (2016):**
 - **Core Functionality:** Enabled ETH transactions and the deployment of **smart contracts** (Ahn et al., 2024). It marked a stabilization phase for the network.
- **Metropolis (Byzantium & Constantinople):**
 - **Improvements:** Focused on improving **security, privacy, and efficiency**. Byzantium, in particular, introduced privacy-preserving technology like zk-SNARKS and delayed the "difficulty bomb," a mechanism designed to encourage the transition to Proof-of-Stake (PoS) (Informatica Unicam, n.d.).
- **London (EIP-1559, 2021):**
 - **Fee Mechanism:** Changed the transaction fee model from a user-bid auction to one with an **algorithmically determined base fee** that gets **burned** (destroyed), plus an optional priority fee (tip) for validators. This was intended to make fees more predictable and manage network congestion (Karaivanov & Zarifian, 2024).
- **The Merge (2022):**
 - **Consensus Shift:** This was the most profound change, where the network transitioned from the energy-intensive **Proof-of-Work (PoW)** consensus mechanism to the more energy-efficient **Proof-of-Stake (PoS)** (Kapengut & Mizrach, 2022).
 - **Impact:** This transition drastically reduced the network's energy consumption (by an estimated 99.98%) and established a consistent block time of 12 seconds, increasing the gas supply (Kapengut & Mizrach, 2022; Karaivanov & Zarifian, 2024).

Future Upgrades (in the current roadmap)

Ethereum's development is often described by the stages: The Merge, The Surge, The Scourge, The Verge, The Purge, and The Splurge.

- **The Surge (Dencun/Cancun-Deneb)(Ongoing – 2023–2025):**
 - **Goal:** Scaling through **sharding** and **Layer 2 (L2) solutions**.
 - introduces “**proto-danksharding**” (EIP-4844) – improves Layer-2 (L2) transaction capacity.
 - Makes **rollups (Optimism, Arbitrum, etc.) cheaper and faster**.
 - Target: handle **100,000+ transactions per second**.
 - Focuses on **data availability and throughput**.
- **The Scourge (Upcoming):**
 - **Goal: Fairness and decentralization** in block production.
 - Addresses **MEV (Maximal Extractable Value)** issues – where validators reorder transactions for profit.
 - Aims to ensure **neutral, credible, and transparent block building**.
 - Introduces **PBS (Proposer-Builder Separation)** to reduce centralization.
 - Strengthens **economic fairness** and network integrity.
- **The Verge (Upcoming):**
 - **Goal: Efficiency and decentralization of validation**.
 - Introduces **Verkle Trees** (an upgrade from Merkle Trees).
 - Makes nodes **lighter and faster** to verify Ethereum’s state.
 - Users can become **validators with minimal storage**, boosting decentralization.
 - Enhances **data verification efficiency**.
- **The Purge (Future):**
 - **Goal: Simplify Ethereum and reduce technical debt**.
 - Removes **old history and redundant data** from the blockchain.
 - Reduces **node storage requirements** → easier to run full nodes.
 - Streamlines the **protocol codebase**, improving long-term maintainability.
 - Makes Ethereum **leaner and more efficient**.
- **The Splurge (Pectra) (Ongoing/Final):**
 - **Goal: Miscellaneous improvements and fine-tuning**.
 - Includes **smaller upgrades and optimizations** not covered in other stages.

- Focuses on **user experience, performance, and minor feature enhancements**.
- Ensures **smooth operation** after the major transformations.