Name: Darshan Bele
Roll No: 14110
Class: BE – A – A1

Survey Report: An Overview of Blockchain Architectures and Their Real-World Applications

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1. Abstract

This report provides a comprehensive survey of the primary types of blockchain architecture: Public, Private, and Consortium. It defines the core characteristics of each type and analyses their respective advantages and disadvantages. The report then explores a range of real-time use cases across various industries, including finance, supply chain management, healthcare, and digital identity, illustrating how blockchain technology is being implemented to solve practical problems.

2. Introduction to Blockchain Technology

At its core, a blockchain is a distributed, immutable digital ledger. Think of it as a shared digital notebook where entries (transactions or data) are recorded in blocks. Each block is cryptographically linked to the one before it, creating a chain. This structure makes the data transparent, secure, and highly resistant to tampering. The objective of this report is to categorize the main blockchain frameworks and highlight their impactful applications in the real world today.

3. Types of Blockchain Architecture

Blockchain is not a one-size-fits-all solution. The architecture chosen depends entirely on the goal of the application, balancing needs for privacy, control, and decentralization.

A. Public Blockchain

A public blockchain is completely open and permissionless. Anyone, anywhere can join the network, read the transaction history, and participate in the consensus process (the mechanism for agreeing on new blocks). It is the original and most decentralized form of blockchain.

- Key Features: Full decentralization, high transparency, and censorshipresistance.
- Analogy: It's like a global public library where anyone can read the books and suggest a new one to add, but no one can alter the existing books.
- Examples: Bitcoin (for peer-to-peer electronic cash) and Ethereum (for smart contracts and decentralized applications).
- Pros: High security through massive decentralization, immutability, and transparency.
- Cons: Low transaction speed (scalability issues), high energy consumption (for Proof-of-Work systems), and lack of privacy.

B. Private Blockchain

A private blockchain, also known as a permissioned blockchain, is controlled by a single organization. The controlling entity determines who can join the network, view the ledger,

and submit transactions. It operates more like a traditional, centralized database but with the cryptographic security of a blockchain.

- Key Features: Centralized control, high privacy, and high transaction speed.
- Analogy: A company's internal server or intranet. Only verified employees can access and modify the data, and all activity is logged.
- Examples: Hyperledger Fabric (hosted by the Linux Foundation) and Corda (by R3), both popular for enterprise solutions.
- Pros: Very fast and scalable, ensures data privacy, and is energy e icient.
- Cons: It's centralized, which reduces trust compared to public networks and makes it more vulnerable to manipulation by the owner.

C. Consortium Blockchain

A consortium blockchain is a semi-decentralized hybrid of public and private models. Instead of one organization, it's governed by a group of pre-selected organizations. This model is ideal for collaboration between di erent companies within the same industry.

- Key Features: Partially decentralized, permissioned access, and shared governance.
- Analogy: A trade association where multiple member corporations share and manage a common database.
- Examples: Marco Polo Network (for trade finance, involving major banks) and the Energy Web Foundation (for the energy sector).
- Pros: O ers a good balance of speed and security, fosters collaboration, and maintains data privacy within the group.
- Cons: Governance can be complex, and there's a risk of collusion among the member organizations.

4. Real-Time Blockchain Use Cases

Blockchain's unique features are being leveraged to innovate across multiple sectors.

Finance: Cross-Border Payments

- Problem: Traditional international payments (via SWIFT) are slow (taking 3-5 days) and expensive due to multiple intermediary banks.
- Blockchain Solution: Companies like Ripple use a consortium blockchain to enable real-time, low-cost international payments by connecting banks directly, bypassing the complex correspondent banking system.
- Blockchain Type Used: Consortium/Private.

Supply Chain Management: Proving Authenticity

- Problem: It's di icult to track a product's journey from origin to consumer, leading to counterfeiting, fraud, and safety issues.
- Blockchain Solution: IBM Food Trust, used by retailers like Walmart, logs produce on a private blockchain. By scanning a QR code, a consumer can see every step of the product's journey, from the farm to the store shelf, ensuring transparency and food safety.
- Blockchain Type Used: Private/Consortium.

Healthcare: Secure Health Records

- Problem: Patient medical records are fragmented across di erent hospitals and clinics, and patients have little control over their own data.
- Blockchain Solution: Platforms like MedRec (an MIT project) create a decentralized system where a patient's medical history is immutably recorded.
  The patient can grant temporary, auditable access to doctors or insurers, giving them full control over their sensitive data.
- Blockchain Type Used: Private/Consortium.

Digital Identity & Voting: Self-Sovereign Identity

- Problem: Our digital identities are controlled by third parties (like Google, Facebook, or governments), creating central points of failure and privacy risks.
- Blockchain Solution: The concept of Self-Sovereign Identity (SSI) allows individuals to store their own identity credentials (like a driver's license or passport) on their personal device and share them verifiably using a blockchain.
  The city of Zug, Switzerland, has trialed this for digital IDs and e-voting.
- Blockchain Type Used: Can be Public (for voting) or Private (for identity).

Feature	Public Blockchain	Private Blockchain	Consortium Blockchain
Access	Permissionless (Anyone can join)	Permissioned (One org controls)	Permissioned (Group controls)
Decentralization	High	None (Centralized)	Partial (Semi-decentralized)
Speed	Low	High	High
Data Privacy	None (Transparent)	High	High (Within the group)
Trust Model	Trust in the network code	Trust in the single entity	Trust in the group consensus
Best For	Cryptocurrencies, dApps, Voting	Internal business operations	B2B collaboration, industry groups

6. Conclusion

The evolution of blockchain technology has moved far beyond its initial application with Bitcoin. The distinction between public, private, and consortium architectures allows for tailored solutions that address specific business needs. While public blockchains o er unparalleled security and transparency for open networks, private and consortium blockchains provide the speed, privacy, and control required for enterprise and B2B applications. As the technology matures, we can expect to see even more innovative, realworld implementations that harness the unique strengths of each blockchain type to build more e icient, transparent, and secure systems.