

Topic 4.4: Tokenization and CBDCs

Digitizing Real-World Assets and Central Bank Digital Currencies

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By the end of this topic, you will be able to:

1. **Define** tokenization and explain its value proposition for real-world assets
2. **Compare** different CBDC architectural models (direct, intermediated, hybrid)
3. **Evaluate** the trade-offs between CBDCs and private stablecoins
4. **Assess** the implications of programmable sovereign money
5. **Analyze** regulatory and privacy challenges in digital currency design

Key Question

How will the digitization of money and assets reshape finance, and what design choices matter most?

Blockchain Fundamentals (T1.3)

Key takeaway: A blockchain is a distributed database where transactions are grouped into blocks and linked cryptographically, making records tamper-resistant without central authority.

Why it matters here:

- Tokenization uses blockchain to create tamper-proof records of asset ownership
- CBDCs leverage blockchain technology for programmable, auditable digital currency
- The trustless nature enables 24/7 trading without intermediaries

Smart Contracts (T4.1)

Key takeaway: Smart contracts are self-executing code on blockchains that automatically enforce agreements when conditions are met—no lawyers or intermediaries needed.

Why it matters here:

- Tokenized assets use smart contracts to automate dividend payments
- CBDCs can use smart contracts for programmable money (e.g., expiring stimulus)
- Security tokens enforce regulatory compliance automatically (KYC/AML)

Stablecoins (T4.3)

Key takeaway: Stablecoins are cryptocurrencies pegged to fiat currency (like the US dollar), providing crypto's speed without volatility. They can be backed by reserves or use algorithms.

Why it matters here:

- CBDCs compete directly with private stablecoins like USDC and Tether
- Both represent digital dollars, but CBDCs are sovereign (government-issued)
- Understanding stablecoin limitations helps explain why CBDCs exist

DeFi Primitives (T4.2)

Key takeaway: DeFi protocols enable lending, borrowing, and trading without banks using smart contracts. They're like financial Lego blocks you can combine.

Why it matters here:

- Tokenized assets can plug into DeFi for instant liquidity
- CBDCs may enable DeFi composability with sovereign money
- Real-world assets + DeFi = the convergence of traditional and crypto finance

Token Standards Explained

ERC-20 & ERC-721 are blueprints that tell tokens how to behave—like using standard electrical outlets so any device works. ERC-20 is for fungible tokens (like currency), ERC-721 for unique tokens (like art NFTs).

Background: The Digitization of Value



Why Now?

- Blockchain provides programmable, trustless infrastructure
- COVID accelerated digital payment adoption globally
- Stablecoins demonstrated demand for digital dollars
- Central banks responding to private digital currency competition

Market Context

Boston Consulting Group projects **\$16 trillion** in tokenized assets by 2030—roughly the size of China's entire economy. Over **130 countries** are exploring CBDCs (research → pilot → limited launch → full launch).

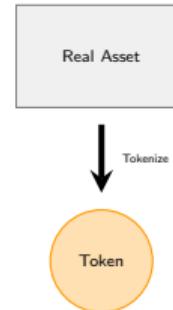
What is Tokenization?

Definition

Tokenization is the process of creating a digital representation of a real-world asset on a blockchain.

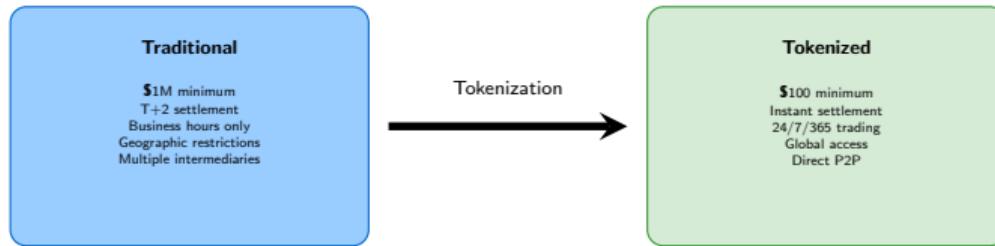
What Can Be Tokenized:

- Real estate
- Securities (stocks, bonds)
- Commodities (gold, oil)
- Art and collectibles
- Intellectual property
- Carbon credits



- ✓ Fractional ownership
- ✓ 24/7 trading
- ✓ Instant settlement
- ✓ Global access

Real-World Asset (RWA) Tokenization



Market Size Projections:

- Boston Consulting Group: \$16 trillion by 2030
- BlackRock, JP Morgan actively building infrastructure
- US Treasuries on-chain: \$1B+ (2024)

The Problem:

- High-value assets require large capital
- Real estate: \$100K+ minimum
- Fine art: \$1M+ for blue-chip pieces
- Private equity: Accredited investors only

The Solution:

- Divide asset into thousands of tokens
- Each token = proportional ownership
- Minimum investment: \$100 or less
- Receive proportional income/returns

Example: Tokenized Real Estate

Property Value: \$1,000,000

Total Tokens: 10,000

Price per Token: \$100

Monthly Rent: \$5,000

Your Investment: 50 tokens (\$5,000)

Your Monthly Income: \$25

Platforms:

- RealT, Lofty (real estate)
- Masterworks (art)
- Securitize (securities)

Asset Class	Platform	What They Do
Real Estate	RealT, Lofty	Buy fractions of rental properties starting at \$50; earn daily rent automatically
US Treasuries	Ondo, Franklin Templeton	Invest in government bonds on-chain; earn 5% yield in your crypto wallet
Private Credit	Centrifuge, Goldfinch	Access corporate loans normally reserved for institutions; 8-15% yields
Commodities	Paxos Gold (PAXG)	Each token = 1 oz gold in vault; trade 24/7 or redeem for physical bars
Art	Masterworks	Own \$5M Banksy for \$100/share; platform handles storage, insurance, resale

The Legal Challenge

Tokens represent claims on assets, but enforcement still requires legal systems. “Code is law” doesn’t apply when real-world assets need real-world courts.

Security Tokens

Definition: Digital representation of traditional securities

- Represent ownership or economic rights
- Subject to securities regulations
- Provide dividends, profit sharing
- Require compliance (KYC/AML)
- Examples: tokenized stocks, bonds, real estate

Utility Tokens

Definition: Access tokens for products/services

- Provide access to platform functionality
- Generally not securities (but varies)
- No ownership or profit rights
- Used within specific ecosystems
- Examples: Filecoin, BAT, Chainlink

The Howey Test¹ (Plain English)

US courts use 4 criteria to determine if something is a security: (1) investment of money, (2) in a common enterprise, (3) with expectation of profits, (4) from others' efforts. If all 4 apply, it's a security requiring SEC² registration.

¹Howey Test = the US legal test (from a 1946 Supreme Court case) for whether something is a security.

²SEC = Securities and Exchange Commission, the main US financial regulator overseeing securities markets.

KYC (Know Your Customer)

What it means: Financial institutions must verify who their customers are before providing services.

- Collect government ID, address proof
- Screen against sanctions lists
- Understand customer's business
- Ongoing monitoring

AML (Anti-Money Laundering)

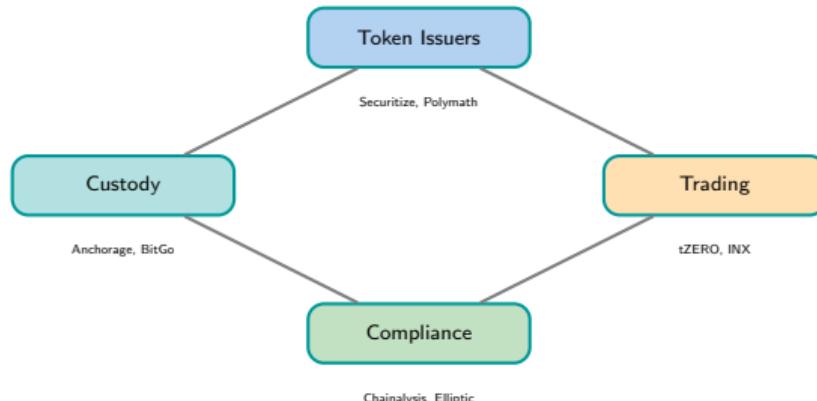
What it means: Rules to prevent criminals from disguising illegally obtained money as legitimate income.

- Monitor suspicious transactions
- Report large transactions (\$10K+ in US)
- Track source of funds
- File SARs (Suspicious Activity Reports)

Why it matters for tokenization:

- Security tokens require full KYC/AML compliance like traditional securities
- Tokenization platforms (Securitize, Polymath) automate compliance checks
- Trade-off: Privacy vs. regulatory legitimacy

Tokenization Infrastructure: Key Players



Securitize and Polymath provide:

- Compliance automation (investor accreditation, KYC/AML)
- Token issuance smart contracts and cap table management
- Automated dividend distributions and regulatory reporting
- Secondary trading platforms

Definition

A CBDC is a digital form of central bank money, denominated in the national unit of account and a direct liability of the central bank.

Global Status (2024):

- **130+ countries exploring**
- **Research:** Studying feasibility (US, UK)
- **Pilot:** Testing with users (China, India)
- **Limited launch:** Small-scale deployment (Nigeria)
- **Full launch:** Nationally available (Bahamas, Jamaica)

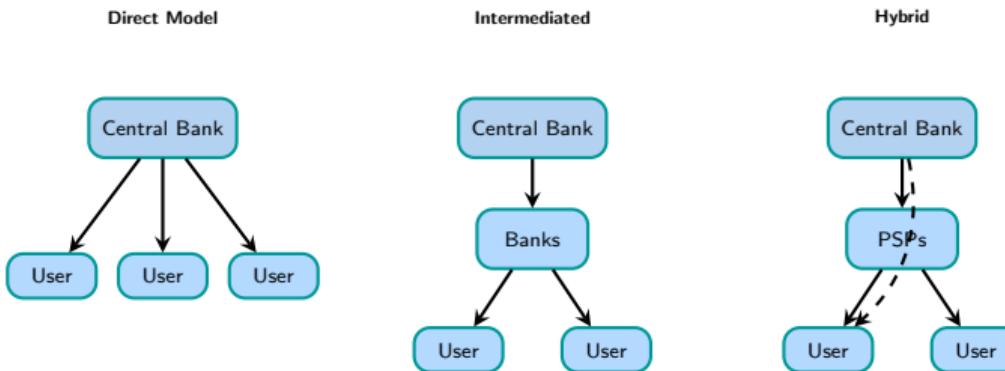
Two Main Types:

Retail CBDC:

- For general public
- Replaces/complements cash
- Direct central bank relationship

Wholesale CBDC:

- For financial institutions
- Interbank settlements
- Less disruptive to banking



Trade-offs:

- **Direct:** Maximum control, but central bank becomes retail bank
- **Intermediated:** Preserves banking system, but less innovative
- **Hybrid:** Balance, but complex implementation

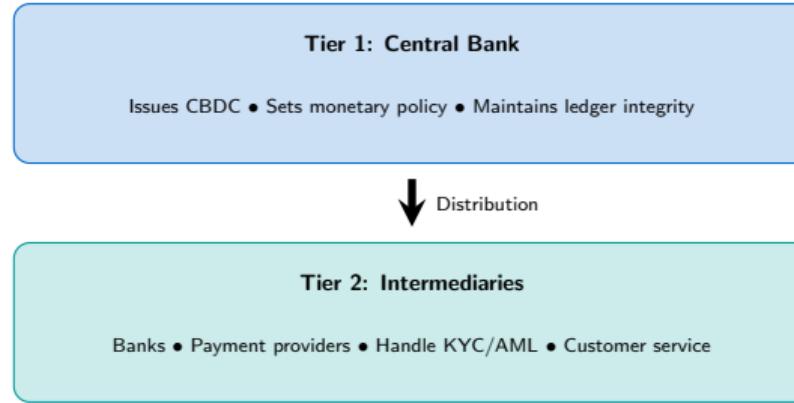
What Does This Mean for YOU?

Direct: Bank at the Federal Reserve directly—your wallet is your Fed account

Intermediated: Keep using Chase/Wells Fargo, but your dollars are CBDCs behind the scenes

Hybrid: Choose either option depending on your needs (both available)

Two-Tier CBDC Architecture



Why Two-Tier?

- Preserves existing financial system structure
- Central bank avoids retail banking operations
- Leverages private sector innovation for customer service
- Similar to how physical cash distribution works today

CBDC vs. Stablecoin Comparison

Attribute	CBDC	Stablecoin
Issuer	Central bank (sovereign)	Private company
Liability	Central bank balance sheet	Private balance sheet
Legal Status	Legal tender	Private money
Backing	Full faith of government	Reserves (varies)
Programmability	Policy-controlled	Open/permissionless
Privacy	Policy-dependent	Pseudonymous (public chains)
Innovation Speed	Slow (government)	Fast (private)
Interoperability	National focus	Global by default
Risk Profile	Sovereign risk only	Counterparty + operational

Key Question

Will CBDCs complement, compete with, or regulate away private stablecoins?

What Programmability Enables:

- Conditional payments
- Automatic tax withholding
- Stimulus with expiration dates
- Supply chain financing
- Smart contract integration

Benefits:

- Financial inclusion for unbanked
- Reduced fraud and money laundering
- Efficient policy transmission
- New business models
- Real-time economic data

Example: Targeted Stimulus

Traditional:

- Send checks to all citizens
- No control over spending
- Slow distribution

Programmable CBDC:

- Instant distribution
- Expires in 90 days
- Only spendable at local businesses
- Automatic for eligible recipients

Privacy and Control Concerns

- **Surveillance:** Complete transaction visibility for governments
- **Control:** Money that can “expire” or be frozen remotely
- **Exclusion:** Programmable discrimination (restricting purchases)
- **Security:** Single point of failure for entire economy

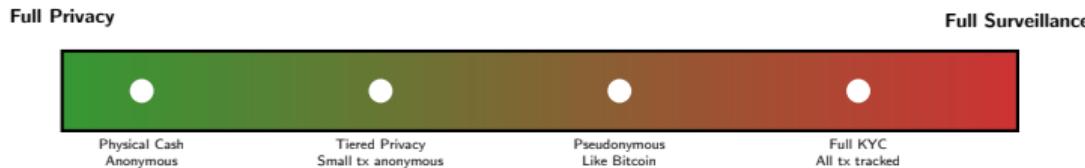
Design Choices That Matter:

- **Token-based vs. Account-based:** Tokens offer more anonymity
- **Privacy-preserving technology:** Zero-knowledge proofs*
- **Offline capability:** Works without internet
- **Holding limits:** Prevent bank disintermediation**
- **Tiered privacy:** Small transactions anonymous, large ones tracked

*Zero-knowledge proofs = a way of proving something is true without revealing the underlying data (e.g., proving you have enough funds without showing your balance).

**Disintermediation = removing banks as middlemen between central banks and customers.

Privacy Design Spectrum



The Fundamental Tension:

- Governments want: AML/KYC compliance, tax enforcement, sanctions
- Citizens want: Financial privacy, freedom from surveillance
- Solution space: Technical privacy (ZK proofs) + legal limits on access

Key Insight

Privacy in CBDCs is a political choice, not a technical limitation. The technology exists for both full surveillance and full privacy.

Why Offline Matters:

- Physical cash works without infrastructure
- Disaster scenarios (hurricanes, earthquakes)
- Rural areas with poor connectivity
- Vulnerable populations without smartphones
- National security resilience

Technical Approaches:

- Hardware wallets with local storage
- NFC*-based peer-to-peer transfer
- Store-and-forward** protocols
- Eventual consistency*** on reconnection

*NFC = Near-Field Communication (tap-to-pay technology).

**Store-and-forward = save the transaction locally, send when internet returns.

***Eventual consistency = the central ledger catches up when devices reconnect.

China's e-CNY Offline

- Hardware wallet cards
- NFC tap-to-pay without internet
- Limited offline balance
- Syncs when reconnected
- Tested in 2022 Olympics

Challenge

Double-spending prevention is harder offline. Solutions involve cryptographic limits and periodic reconciliation.

Status (2024):

- 260+ million wallets created
- Billions in transaction volume
- Integrated with Alipay/WeChat Pay
- Tested in 2022 Beijing Olympics

Key Features:

- Centralized architecture
- “Controlled anonymity” model
- Offline hardware wallet cards
- Programmable “red packet” gifts
- Cross-border pilots (Hong Kong, Thailand)

Design Philosophy

- Complement, not replace, existing payments
- Two-tier distribution via banks
- Central bank maintains ultimate control
- Privacy tiers based on wallet type

Geopolitical Implications:

- Potential alternative to USD system
- Cross-border settlement without SWIFT
- First-mover advantage in CBDC standards

ECB Timeline:

- 2021: Investigation phase launched
- 2023: Preparation phase began
- Late 2020s: Potential launch

Design Priorities:

- Privacy protection (transactions not visible to ECB)
- Offline capability
- Coexistence with physical cash
- Two-tier distribution through banks
- Holding limits to prevent bank runs

Key Concerns Addressed

- **Privacy:** Strong legal protections
- **Banks:** Won't disintermediate
- **Cash:** Complement, not replace
- **Control:** Democratic oversight

Contrast with China:

- Slower, more deliberate approach
- Greater emphasis on privacy
- Democratic accountability
- Political approval required

Federal Reserve Position:

- Research and public consultation phase
- No commitment to issue CBDC
- Requires Congressional authorization
- Prioritizes careful deliberation over speed

Key Concerns:

- Bank disintermediation risk
- Privacy protection
- Cybersecurity vulnerabilities
- Dollar's global reserve status
- Political controversy

Political Divide

- **Supporters:** Financial inclusion, payment efficiency
- **Opponents:** Surveillance concerns, government overreach

Alternative Approach:

- Regulated stablecoins instead?
- FedNow instant payments (2023)
- Private sector innovation
- Watch and learn from others

What is mBridge?

- Multi-CBDC platform by BIS Innovation Hub
- Participants: China, Hong Kong, Thailand, UAE, Saudi Arabia
- Enables direct central bank-to-central bank settlements

Problems Solved:

- Correspondent banking is slow (days)
- High fees (3-5% for remittances)
- USD intermediation required
- Limited operating hours

mBridge Benefits

- Instant, 24/7 settlement
- Direct currency exchange
- Lower transaction costs
- No USD intermediation
- Common technical platform

Geopolitical Significance:

- Alternative to SWIFT
- Reduces dollar dominance
- New monetary architecture

The Convergence Thesis: Traditional finance (TradFi) and decentralized finance (DeFi) are converging. The future is not “either/or” but hybrid systems combining the best of both.

Token = Claim on Asset

- Blockchain state \neq legal reality
- Smart contracts can't seize physical property
- Courts must enforce real-world claims
- Cross-jurisdictional complexity

Key Challenges:

- Securities classification (Howey Test)
- Custody and private key management
- Settlement finality questions
- Investor protection requirements

The Dual Reality Problem

Blockchain says: Alice owns 100 tokens representing 1% of building

Legal question: What happens when:

- Alice loses her private key?
- The building is damaged?
- Local laws change?
- Token issuer goes bankrupt?

Solution: Legal wrappers, regulated custodians, clear jurisdiction

Case Study: Franklin Templeton On-Chain Fund

Background:

- Franklin Templeton: \$1.5T+ AUM
- Launched OnChain U.S. Government Money Fund
- First SEC-registered fund using blockchain
- Shares recorded on Stellar and Polygon

How It Works:

- Fund invests in US government securities
- Each token = one share of fund
- Transfers settle on blockchain
- SEC-registered and compliant

Significance

- Major TradFi validates blockchain
- Regulatory approval achieved
- Real yield on-chain
- DeFi composability potential

Lessons:

- Compliance is possible
- Hybrid models work
- Institutional adoption growing
- Infrastructure maturing

Case Study: Bahamas Sand Dollar

Background:

- First fully deployed retail CBDC (2020)
- Population: 400,000 across 700 islands
- Challenge: Banking access on remote islands

Design Choices:

- Two-tier distribution through banks
- Mobile wallet-based
- Holding limits: \$500 (unverified), \$8,000 (verified)
- Transaction limits for privacy tiers

Results

- Improved financial inclusion
- Faster hurricane relief distribution
- Lower remittance costs
- Limited adoption (under 1% of currency)

Lessons Learned:

- Technology is the easy part
- Adoption requires incentives
- Education is critical
- Existing systems compete

Platform Overview:

- Tokenizes US rental properties
- Minimum investment: \$50
- Daily rental income distribution
- Secondary trading on Uniswap

Structure:

- Each property = separate LLC
- Tokens = LLC membership interests
- Smart contracts automate distributions
- Legal ownership via Delaware LLC

Benefits Demonstrated

- Global investors access US real estate
- Daily income (vs. monthly traditional)
- Transparent on-chain accounting
- 24/7 liquidity via DEXs

Limitations:

- US accredited investors only (initially)
- Regulatory complexity
- Property management still needed
- Market risk remains

Case Study: Nigeria's eNaira Challenges

Background:

- Launched October 2021
- Africa's first CBDC
- Goal: Financial inclusion for 36M unbanked

What Went Wrong:

- Only 0.5% of population adopted (2023)
- Cash withdrawal limits to force adoption
- Public backlash and protests
- Trust deficit with government

Key Lessons

- Can't force CBDC adoption
- Trust is prerequisite
- Cash restrictions backfire
- Infrastructure must exist

Contrast with Success:

- India's UPI (not CBDC) succeeded
- Voluntary adoption works better
- Incentives & mandates
- Build on existing behavior

Discussion: Should Central Banks Issue Retail CBDCs?

Arguments FOR:

- Preserve public money option as cash declines
- Financial inclusion for unbanked
- More efficient monetary policy
- Counter private stablecoin dominance
- Reduce payment system costs
- Enable programmable fiscal policy

Arguments AGAINST:

- Privacy and surveillance concerns
- Bank disintermediation risk
- Cybersecurity vulnerabilities
- Operational burden on central banks
- Existing systems work adequately
- Political weaponization risk

Discussion Questions

- Would you trust a government-issued digital currency?
- How should programmable money be governed?
- What privacy guarantees are non-negotiable?

Due Diligence Framework

1. **Legal Structure:** Does the token legally represent the claimed asset?
2. **Custody:** Who holds the underlying asset? What happens if they fail?
3. **Regulatory Compliance:** Is the offering properly registered?
4. **Liquidity:** Can you actually sell the token when needed?
5. **Audit Trail:** Are reserves/assets independently verified?
6. **Jurisdiction:** Where would disputes be resolved?

Red Flags:

- Unclear legal structure or offshore entities
- No independent audits of underlying assets
- Promises of guaranteed returns
- No regulatory registration for securities-like tokens

Asset Tokenization:

- Creates digital representations of real assets
- Enables fractional ownership and 24/7 trading
- \$16T projected market by 2030
- Legal enforcement still requires courts

CBDCs:

- Digital sovereign currency
- 130+ countries exploring
- Retail vs. wholesale types
- Design choices determine privacy

Key Trade-offs:

- Privacy vs. compliance
- Innovation vs. stability
- Inclusion vs. control
- National vs. global systems

The Bottom Line:

- Programmable money is coming
- Design choices are political
- TradFi and DeFi converging
- Regulatory clarity emerging

Key Terms (1/2)

Tokenization Creating digital blockchain representations of real-world assets

RWA Real-World Assets - physical or traditional financial assets represented as tokens

Security Token Token representing ownership in an asset, subject to securities laws

Utility Token Token providing access to a product or service, not ownership

CBDC Central Bank Digital Currency - digital sovereign money issued by central bank

Retail CBDC Digital currency for general public use

Wholesale CBDC Digital currency for financial institution settlements

Two-Tier Architecture CBDC distributed through intermediaries, not directly by central bank

Key Terms (2/2)

Programmable Money Currency with embedded rules controlling spending/expiration

Fractional Ownership Dividing asset ownership into small tradeable units

Interoperability Ability of different digital currency systems to work together

mBridge Multi-CBDC platform for cross-border central bank settlements

e-CNY China's digital yuan CBDC

Digital Euro ECB's planned CBDC for the Eurozone

Offline Capability CBDC function without internet connectivity

Howey Test Legal test determining if an asset is a security

Misconception 1

“Tokenization eliminates all investment risks”

Reality: Tokenization changes access and liquidity, not underlying asset risk. A tokenized building can still lose value.

Misconception 2

“CBDCs are just like cryptocurrency”

Reality: CBDCs are centralized, sovereign money. They share technology but not philosophy with decentralized crypto.

Misconception 3

“Code is law for tokenized assets”

Reality: Physical assets require physical enforcement. Smart contracts can't seize a building—courts can.

Misconception 4

“CBDCs will replace cash immediately”

Reality: Most central banks plan CBDCs to complement, not replace cash. The ECB explicitly guarantees cash availability.

Question (From Quiz 4.4, Q3)

What is the primary benefit of fractional ownership through tokenization?

- A) It eliminates all investment risk
- B) It lowers barriers to entry by allowing investors to own small portions of high-value assets, democratizing access to investments previously limited to wealthy individuals
- C) It guarantees higher returns on investment
- D) It removes the need for legal contracts

Question (From Quiz 4.4, Q3)

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- D) It removes the need for legal contracts

Answer: B

Fractional ownership enables multiple investors to own portions of high-value assets. Instead of needing \$1 million to buy a property, tokenization allows investments of \$100 or \$1,000 while maintaining liquidity through secondary trading.

Q2 (Quiz 4.4, Q9): Direct vs. Intermediated CBDC Models

In direct models, citizens hold accounts directly with the central bank; in intermediated models, commercial banks or PSPs manage customer relationships. **Answer: B**

Q3 (Quiz 4.4, Q18): Tokenization Platforms

Platforms like Securitize and Polymath provide infrastructure and compliance tools for issuing, managing, and trading security tokens in compliance with securities regulations. **Answer: B**

Key Insights:

- Direct CBDC models create operational burden; intermediated models preserve banking roles
- Tokenization platforms bridge traditional securities law with blockchain technology
- Both represent the institutionalization of digital finance infrastructure

Day 5: Risk and Regulation in Digital Finance

Topics to be covered:

- T5.1: Crypto market risks and volatility analysis
- T5.2: Smart contract security and audit frameworks
- T5.3: Global regulatory landscape (MiCA, SEC, international)
- T5.4: Compliance, AML/KYC, and institutional frameworks

Connection to Today's Content:

- How are tokenized assets regulated differently from native crypto?
- What compliance requirements apply to security tokens?
- How do CBDCs fit into existing financial regulation?
- What risks are unique to programmable money?

Resources for Further Learning

Academic & Research:

- BIS Papers on CBDCs: bis.org/cbdc
- Atlantic Council CBDC Tracker: atlanticcouncil.org/cbdctracker
- ECB Digital Euro Documentation: ecb.europa.eu/paym/digital_euro

Industry Reports:

- BCG “Relevance of On-chain Asset Tokenization”
- McKinsey “Tokenization: A Digital-Asset Deja Vu”
- World Economic Forum “Digital Currency Governance Consortium”

Tokenization Platforms:

- Securitize, Polymath (security tokens)
- RealT, Lofty (real estate)
- Ondo Finance (treasury tokens)

Topic 4.4: Tokenization and CBDCs

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Questions & Discussion

Next: Day 5 – Risk and Regulation in Digital Finance