Lesson 6.1: Payment Rails and Clearing Infrastructure

Module 6: The Infrastructure Problem

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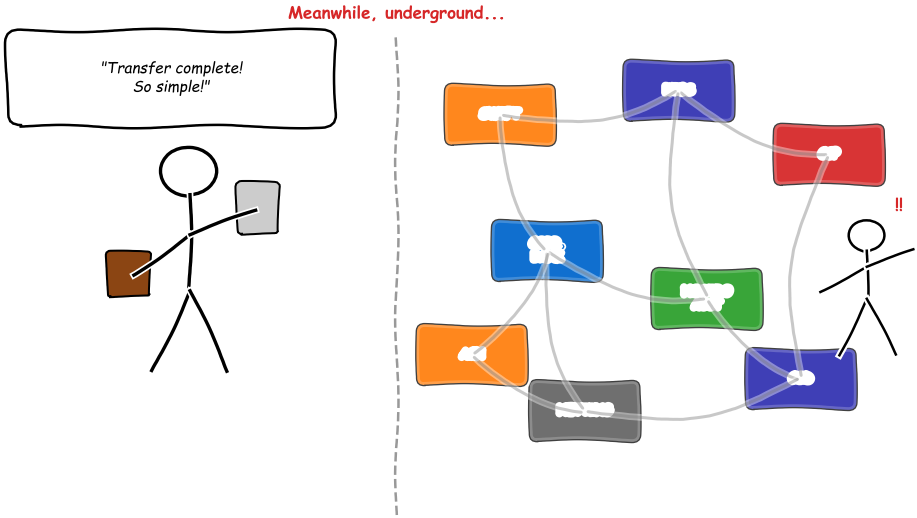
Digital Finance — BSc Course

The Plumbing Nobody Sees



$5 trillion moves daily through pipes nobody thinks about

Learning Objectives

After completing this lesson, you will be able to:

1. **Explain** the role of payment rails (ACH, RTGS, SWIFT) in moving money between institutions [Understand]
2. **Distinguish** between clearing and settlement and describe why they are separate processes [Understand]
3. **Trace** a cross-border payment through the correspondent banking network [Apply]
4. **Calculate** the netting benefit of a central counterparty (CCP) [Apply]
5. **Evaluate** the trade-offs between gross (RTGS) and net (DNS) settlement systems [Analyze]

Bloom's levels covered: Understand, Apply, Analyze

Objectives follow Bloom's taxonomy: Understand → Apply → Analyze.

From “What” to “How”

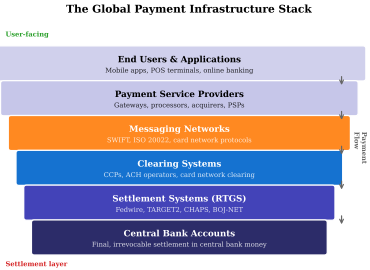
So far we covered what finance does:

- M1 Cost: why payments are expensive
- M2 Access: who gets served by finance, who does not
- The economic forces that shape financial services

Module 6 asks: how does the machinery actually work?

- What **physical and logical infrastructure** moves trillions of dollars daily?
- Why do transfers still take T+1 or T+2?
- Who ensures that money actually arrives?
- What happens if an intermediary fails mid-transfer?

Teaching sequence: M2 Access → **M6 Infrastructure** (here) → M3 Trust next.



The global payment stack: layers of infrastructure that underpin every transaction.

Infrastructure is invisible when it works — and catastrophic when it fails.

What Are Payment Rails?

Definition: Payment Rail

A **payment rail** is the underlying network or system through which money moves between financial institutions. It defines the **rules**, **message formats**, and **settlement mechanisms** for a class of transactions.

Major payment rails worldwide:

Rail	Type	Speed	Typical Use
ACH (US) / SEPA (EU)	Batch / DNS	Hours–days	Payroll, bill pay, direct debit
Fedwire (US) / TARGET2 (EU)	RTGS	Minutes	Large-value, interbank
SWIFT	Messaging layer	Varies	Cross-border instructions
Card networks	Proprietary	Seconds (auth)	Consumer POS payments
RTP (TCH, 2017+)	Real-time	Seconds	US instant retail
FedNow (2023+)	Real-time	Seconds	US instant, Fed-operated, $500K limit
FPS / UPI / PIX	Real-time	Seconds	UK / India / Brazil instant retail

FedNow reached ∼1,400–1,500 (Federal Reserve, 2025) participating institutions by late 2025 (Fed Bank Services updates); volume still small vs. TCH RTP but accelerating.

Data reviewed: April 2026. Source: frbservices.org; TCH RTP.org. Rails differ in speed, cost, finality, and design purpose.

ACH: The Batch-Processing Workhorse

Automated Clearing House (ACH):

- Processes **batch** payments — not real-time
- Handles payroll, recurring bills, government benefits, direct debits
- In the US: ∼33.6 billion (*NACHA*, 2024) ACH transactions in 2024, totalling ∼$86.2 trillion (*NACHA Annual Statement*, 2024); Same-Day ACH ∼1.2 billion (*NACHA*, 2024) transactions / $2.6T
- In the EU: SEPA Credit Transfer and SEPA Direct Debit serve an equivalent role

How ACH works:

1. Originator submits payment file to its bank (Originating Depository Financial Institution (ODFI))
2. ODFI forwards file to the ACH operator
3. ACH operator sorts, nets, and distributes files to receiving banks (Receiving Depository Financial Institution (RDFI))
4. RDFI credits/debits customer accounts

ACH characteristics:

Speed	Same-day or next-day	
Cost	$0.20–$1.50/txn	
Settlement	Deferred net (DNS)	**Key**
Finality	Reversible (returns)	
Limit	No hard cap	

insight: ACH is cheap and high-volume, but **not irrevocable** — returns can occur days later.

Data reviewed: April 2026. Source: NACHA Annual Statement 2024 (released March 2025). ACH handles more transactions than any other US payment rail — but its batch design creates settlement delays.

RTGS: Real-Time Gross Settlement

Definition: RTGS

A **Real-Time Gross Settlement** system settles each payment **individually** and **immediately** in central bank money, without netting. Once settled, the payment is **final and irrevocable**.

Why RTGS matters:

- Eliminates **settlement risk** — the payee has guaranteed central bank money
- Used for large-value, time-critical transfers (interbank, securities settlement)
- Every major economy operates at least one RTGS system

Examples:

System	Jurisdiction	Daily Volume (approx.)
Fedwire Funds	United States	\$4+ trillion
TARGET2	Eurozone	€2+ trillion
CHAPS	United Kingdom	£400+ billion
BOJ-NET	Japan	¥150+ trillion

RTGS systems are the backbone of financial stability — failure would halt interbank money movement.

DNS vs. RTGS: Two Settlement Philosophies

Deferred Net Settlement (DNS):

- Payments accumulated over a period
- **Netting** reduces total transfers
- Settlement at designated times (e.g., end of day)
- Lower liquidity requirement
- Risk: If one participant defaults before settlement, all positions unwind

Note: DNS here refers to Deferred Net Settlement in payment systems, not Domain Name System.

Example: ACH, BACS, card network settlement

Real-Time Gross Settlement (RTGS):

- Each payment settled individually
- **No netting** — gross amounts transferred
- Settlement is immediate and final
- Higher liquidity requirement
- Benefit: No credit risk between participants

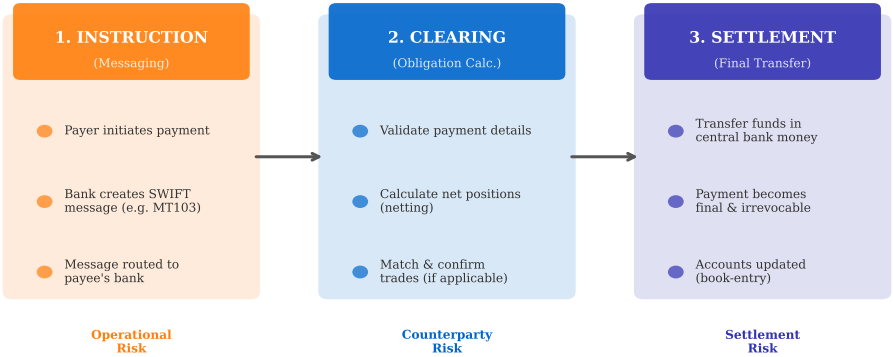
Example: Fedwire, TARGET2, CHAPS

The trade-off: DNS is liquidity-efficient but risky. RTGS is safe but liquidity-expensive.

Modern hybrid systems combine elements of both: real-time processing with periodic netting cycles.

Clearing vs. Settlement: The Critical Distinction

Clearing vs. Settlement: Three Stages of Every Payment



Definitions

Clearing is the process of calculating mutual obligations — who owes what to whom.
Settlement is the actual transfer of money (or securities) to discharge those obligations.

The Three Stages of a Payment

Every interbank payment passes through three stages:

Stage	Name	What Happens
1	**Instruction / Messaging**	The payer's bank sends a payment message (e.g., via SWIFT) to the payee's bank
2	**Clearing**	Obligations are calculated: netting positions, validating details, matching trades
3	**Settlement**	Final, irrevocable transfer of funds between accounts at the central bank or settlement agent

Key risks at each stage:

- **Messaging:** Operational risk (wrong amount, wrong account)
- **Clearing:** Counterparty risk (one party cannot fulfill obligation)
- **Settlement:** Settlement risk (failure to deliver funds/securities on time)

Understanding these stages is essential for diagnosing where failures occur and where FinTech can improve.

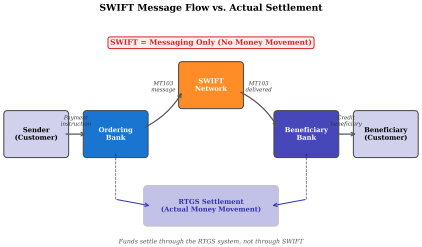
SWIFT: The Global Messaging Network

What SWIFT is:

- The Society for Worldwide Interbank Financial Telecommunication
- A **messaging network** connecting 11,000+ institutions in 200+ countries
- SWIFT **does not move money** — it sends **instructions** between banks
- Founded in 1973 to replace Telex; headquartered in Belgium

What SWIFT is NOT:

- NOT a payment rail (no accounts, no settlement)
- NOT a clearing house
- NOT a regulator



A SWIFT MT103 message instructs the beneficiary bank to credit the payee.

SWIFT carries ∼45 million messages per day — but the actual money moves through RTGS and correspondent bank accounts.

SWIFT Message Types and ISO 20022

Key SWIFT message categories (Message Type (MT) format):

Category	Code	Purpose
Customer transfers	MT103	Single customer credit transfer
Bank-to-bank	MT202	General financial institution transfer
FX confirmation	MT300	Foreign exchange trade confirmation
Securities	MT54x	Securities settlement instructions
Statements	MT940/950	Account statements

The ISO 20022 migration — status April 2026:

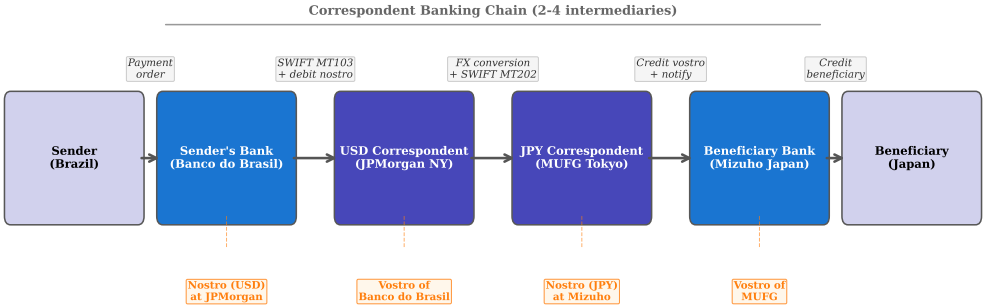
- SWIFT migrated cross-border payment traffic from MT (MT103, MT202) to **ISO 20022** (MX / CBPR+); the FINplus coexistence period **ended November 2025**
- MT103 and MT202 cross-border messages are **no longer supported**; stragglers face rejection and community-service translation fees
- Adoption: ∼95% (*SWIFT community*, 2025) of SWIFT members migrated by the deadline
- Domestic systems: Fedwire ISO 20022 (March 2025 (*Fedwire*, 2025)), CHAPS (June 2023 (*Bank of England*, 2023)), TARGET2 (March 2023 (*ECB*, 2023)) — now interoperating on common schema
- **Impact:** Structured data → fewer manual repairs, better AML/sanctions screening, faster straight-through processing

Data reviewed: April 2026. Sources: SWIFT "ISO 20022: the deadline and beyond"; Fedwire, Bank of England, ECB migration announcements. ISO 20022 is the most significant upgrade to financial messaging in 50 years.

Correspondent Banking: A Cross-Border Payment Chain

Cost: 1-5% in fees and FX spread

Time: 2-5 business days | Each hop adds cost + delay



Nostro and Vostro Accounts

Correspondent banking relies on paired accounts:

Account	Definition	Example
Nostro ("ours")	Our account held at a foreign bank	Deutsche Bank's USD account at JPMorgan
Vostro ("yours")	Your account held at our bank	JPMorgan's view of the same account

Key characteristics:

- The same account is a *nostro* from one bank's perspective and a *vostro* from the other's
- Banks must **pre-fund** nostro accounts in each currency they need — tying up liquidity
- Global banks maintain hundreds of nostro accounts across dozens of currencies
- **Problem:** Trapped liquidity, reconciliation costs, and time-zone mismatches create friction

Nostro account management is one of the most operationally complex and capital-intensive activities in banking.

Payment Finality: When Is a Payment "Done"?

Definition: Payment Finality

Payment finality is the point at which a payment becomes **irrevocable and unconditional** — it cannot be reversed, even if the payer subsequently becomes insolvent.

Finality varies by system:

System	Finality	Implication
RTGS (Fedwire)	Immediate	Irrevocable upon processing
ACH	Deferred	Returns possible for 2–60 days
Card networks (Point of Sale (POS))	Conditional	Chargebacks possible for 120 days
Wire transfers	Upon settlement	Final after central bank settlement
Blockchain	Probabilistic	"Final" after N confirmations

Why finality matters: Without legal certainty that a payment is irrevocable, the recipient bears the risk that it could be clawed back.

Finality is the legal and operational foundation of trust in the payment system.

Central Counterparty (CCP): The Middleman by Design

Definition: Central Counterparty

A **Central Counterparty (CCP)** interposes itself between two trading parties through **novation**: the original contract between A and B is replaced by two contracts — A-to-CCP and CCP-to-B. The CCP becomes the buyer to every seller and the seller to every buyer.

Why CCPs exist:

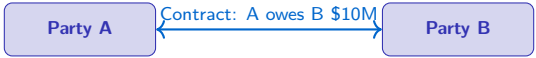
- **Counterparty risk mitigation:** If B defaults, the CCP still pays A
- **Multilateral netting:** Instead of bilateral nets, the CCP calculates one net position per participant
- **Margin management:** CCP collects initial and variation margin from all participants
- **Default management:** CCP has a "waterfall" of resources to absorb losses

Risk: CCPs concentrate systemic risk — if a CCP fails, the entire market is affected.

After the 2008 crisis, G20 mandated central clearing for standardized derivatives — making CCPs systemically important.

Novation: How the CCP Interposes Itself

Before novation (bilateral):

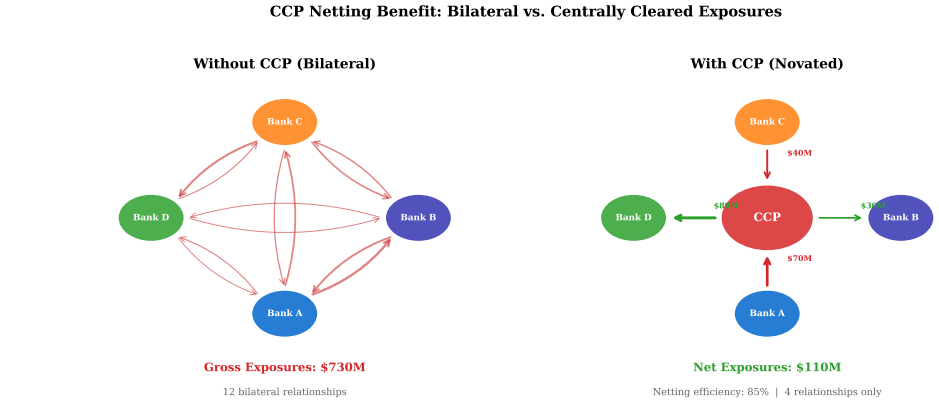


After novation (centrally cleared):

Key point: The original A–B contract is legally **replaced** by two new contracts. Neither A nor B faces the other — both face the CCP.

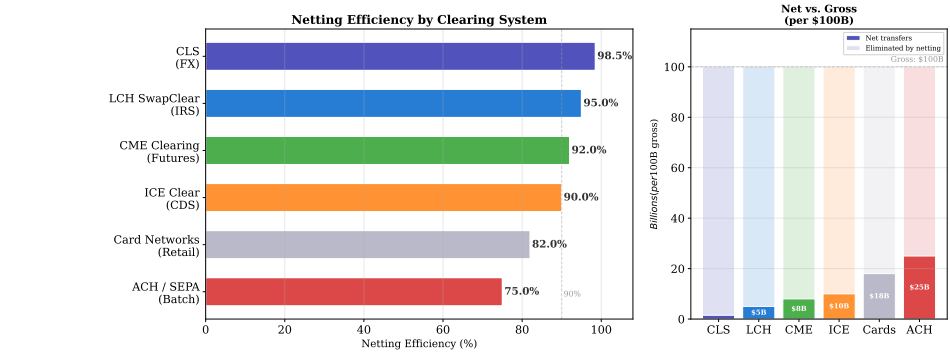
Novation transfers counterparty risk from bilateral participants to the CCP, which manages it with margin and default funds.

The Netting Benefit of a CCP



- **What you see:** Without CCP (left), 4 banks have 12 bilateral relationships — each pair trades directly. With CCP (right), all 4 banks face only the CCP
- **Key pattern:** Gross exposures total $840M in bilateral model; after multilateral netting through the CCP, net flows drop to $90M
- **Takeaway:** The CCP reduces gross exposures by 89%, freeing capital and reducing counterparty risk — but concentrates systemic risk at the CCP

Netting Efficiency: Quantifying the Benefit



- **What you see:** Left panel shows netting efficiency percentages (CLS: 98.5%, LCH: 95%, ACH: 75%). Right panel shows that for $100B gross, CLS nets down to just $1.5B
- **Key pattern:** FX and derivatives clearing achieve 95–98% netting; retail payment systems (cards, ACH) achieve 75–82%
- **Takeaway:** Higher netting efficiency frees liquidity for participants — $98.5B not needed for settlement per $100B gross volume

$$\textbf{Netting ratio} = \frac{\text{Gross obligations} - \text{Net obligations}}{\text{Gross obligations}} \times 100\%$$

Example: If Bank A has gross obligations of $100M but after bilateral netting owes only $5M, netting ratio

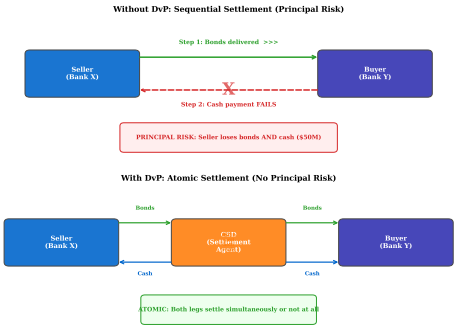
Delivery vs. Payment (DvP)

Definition: DvP

Delivery vs. Payment (DvP) is a settlement mechanism that ensures the transfer of securities occurs **if and only if** the corresponding payment occurs. Neither leg can settle independently.

Why DvP is critical:

- Eliminates **principal risk**: the risk that one party delivers but the other does not pay
- Without DvP: If Bank A delivers bonds but Bank B fails to pay, Bank A loses the full principal
- With DvP: Either both legs settle, or neither does



Securities and cash move simultaneously — atomic settlement.

DvP is the gold standard for securities settlement — mandated by regulators worldwide.

Central Securities Depositories (CSDs)

Definition: CSD

A **Central Securities Depository (CSD)** provides the **safekeeping** of securities (equities, bonds, etc.) in dematerialized (electronic) form and operates the **settlement infrastructure** for securities transactions.

Key CSD functions:

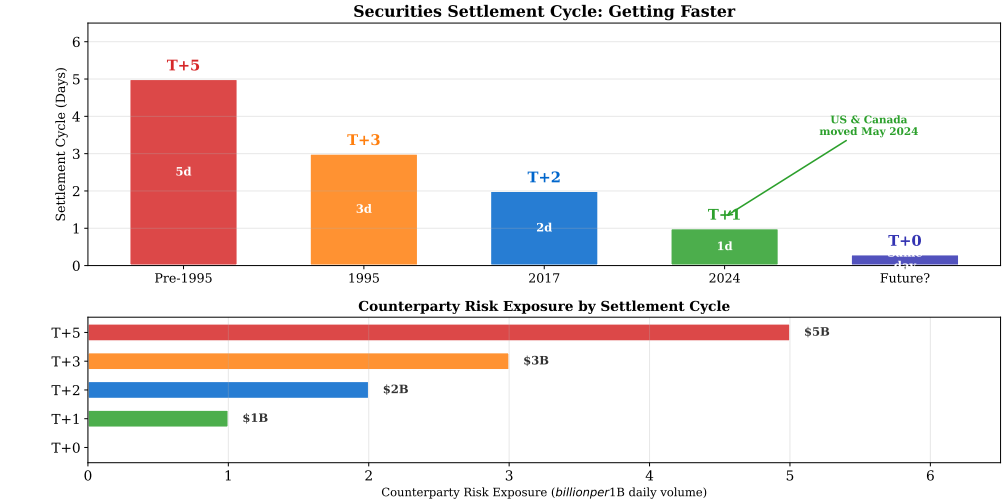
1. **Notary:** Records the issuance of new securities
2. **Safekeeping:** Maintains the definitive register of ownership
3. **Settlement:** Executes book-entry transfers between participants' accounts

Major CSDs:

CSD	Jurisdiction	Assets (approx.)
DTCC (DTC)	United States	\$87 trillion
Euroclear	Europe (ICSD)	€37 trillion
Clearstream	Europe (ICSD)	€16 trillion

CSDs are the ultimate "book of record" for who owns what — they are critical infrastructure.

The Move to T+1: Faster Securities Settlement



- **What you see:** Top panel shows settlement cycles from T+5 (pre-1995) to T+0 (future). Bottom panel shows counterparty risk exposure drops proportionally: T+2 = $2B exposure, T+1 = $1B

Definition: Settlement Risk (Herstatt Risk)

Settlement risk is the risk that one party delivers its side of a trade but the other party fails to deliver the corresponding leg. In FX, this is called **Herstatt risk**, named after the 1974 failure of Bankhaus Herstatt, which received DEM payments in Frankfurt but failed before making the corresponding USD payments in New York.

The Herstatt failure (26 June 1974):

1. German banks paid DEM to Herstatt during Frankfurt business hours
2. German regulators closed Herstatt at 3:30 PM Frankfurt time
3. This was 10:30 AM in New York — Herstatt's USD payments had not yet been made
4. Counterparties lost their full principal: they paid DEM but never received USD

Legacy: Herstatt risk motivated the creation of CLS Bank (2002) for PvP FX settlement.

The Herstatt failure demonstrated that time-zone differences create a window of principal risk in FX.

Payment vs. Payment (PvP) and CLS Bank

CLS Bank eliminates FX settlement risk through PvP:

- **Payment vs. Payment (PvP):** Both legs of an FX trade settle simultaneously — or not at all
- CLS settles 18 currencies with **over $6 trillion in FX obligations daily**
- Netting efficiency: CLS reduces gross obligations by **98%+**

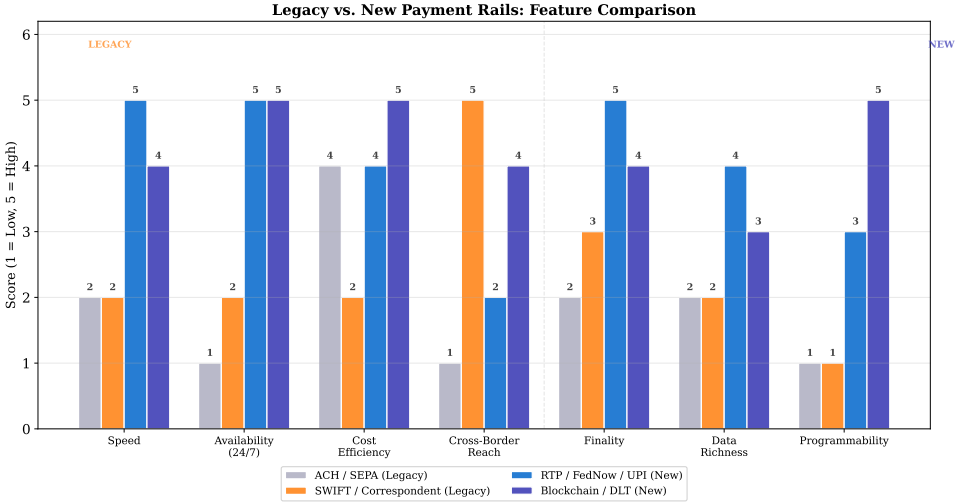
How CLS works:

1. Both parties submit payment instructions to CLS before the settlement date
2. CLS multilaterally nets all instructions across all 18 currencies
3. On settlement day, each participant pays in its net short currencies and receives its net long currencies
4. CLS releases both legs **simultaneously** — PvP is achieved

Result: Principal risk in FX is virtually eliminated for CLS-settled currencies.

CLS Bank is a single-purpose financial market utility — its only job is to eliminate FX settlement risk.

Legacy vs. New Rails: The Infrastructure Shift



New rails are emerging alongside legacy systems:

- **Instant payment systems** (RTP, FedNow, SEPA Instant) offer 24/7 real-time settlement

The CCP Default Waterfall

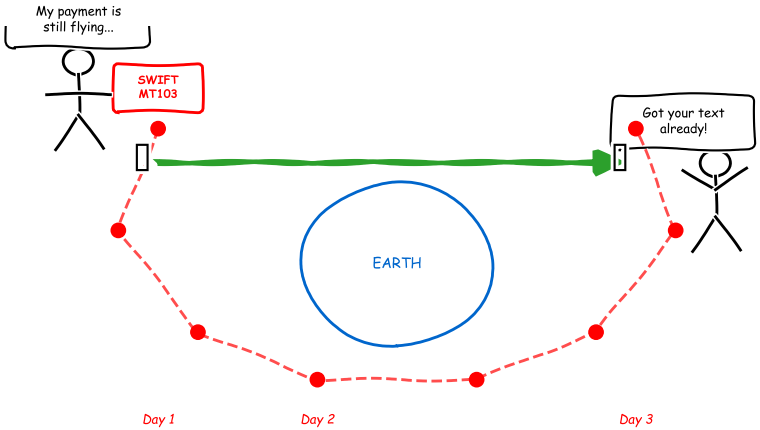
When a clearing member defaults, the CCP absorbs losses in a strict sequence:

Layer	Resource	Description
1	Defaulter's margin	Initial margin posted by the defaulting member
2	Defaulter's default fund contribution	Pre-funded loss-absorbing capital
3	CCP's "skin in the game"	CCP's own equity contribution
4	Non-defaulting members' fund	Mutualized loss-sharing pool
5	CCP's remaining equity	Last-resort CCP capital
6	Recovery / resolution	Powers of assessment, tear-up, or resolution authority

Systemic concern: If losses exceed the waterfall, surviving members bear the cost — making CCPs "too important to fail."

The CCP waterfall is designed to make default manageable — but extreme scenarios can exhaust all layers.

One Last Thought...



Payment infrastructure: where $1 million moves slower than a cat video

Sometimes the best way to remember a concept is to laugh about it.

Key Takeaways

1. **Payment rails** (ACH, RTGS, SWIFT, card networks) are the infrastructure that moves money between institutions
2. **SWIFT is a messaging network**, not a payment rail — it sends instructions; RTGS systems settle them
3. **Clearing** calculates obligations; **settlement** discharges them — these are separate processes with separate risks
4. **Correspondent banking** enables cross-border payments through chains of nostro/vostro accounts
5. **CCPs** interpose themselves via novation, enabling multilateral netting and reducing counterparty risk
6. **DvP** (securities) and **PvP** (FX) eliminate principal risk by linking both legs of a transaction
7. **Payment finality** varies by system — RTGS is immediate; ACH and cards are conditional/reversible
8. The shift from **T+2 to T+1** reduces risk but demands faster operational processes

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Infrastructure determines the speed, cost, and safety of every financial transaction.

Key Vocabulary

- Payment rail
- ACH / SEPA
- RTGS (Fedwire, TARGET2)
- SWIFT (MT103, ISO 20022)
- Correspondent banking
- Nostro / Vostro accounts
- Clearing vs. settlement
- Payment finality
- Central Counterparty (CCP)
- Novation
- Multilateral netting
- Delivery vs. Payment (DvP)
- Payment vs. Payment (PvP)
- Central Securities Depository (CSD)
- Herstatt risk
- T+1 / T+2 settlement
- CLS Bank
- Default waterfall

These terms form the foundation for understanding financial market infrastructure.

Summary / Next Lesson Preview

This lesson: We explored the infrastructure that moves money and securities — payment rails, clearing houses, CCPs, CSDs, and the messaging networks that connect them.

Central insight: Financial infrastructure is a stack of interdependent systems. Each layer (messaging, clearing, settlement) serves a distinct function and carries distinct risks. FinTech innovation targets specific layers — but replacing infrastructure is orders of magnitude harder than replacing a consumer app.

Next lesson (M6L2): *Interoperability and Standards* — We will examine how payment systems talk to each other, why interoperability is the hardest problem in financial infrastructure, and how standards like ISO 20022 and APIs are enabling the next generation of connectivity.

Review: Can you trace a cross-border payment through SWIFT → correspondent banks → RTGS settlement?

Common Misconceptions About Payment Rails

Misconception	Reality
"SWIFT moves money"	SWIFT moves *messages*, not money. Settlement happens on correspondent bank accounts (nostro/vostro) and central bank RTGS.
"Cross-border payments are slow because of technology"	Most of the delay is correspondent-bank AML/sanctions screening (human review) plus timezone-gated cutoffs — not the messaging rail.
"Instant payments means instant settlement"	Depends on the system. SEPA Instant = final settlement in 10 seconds on central-bank money. Many "instant" retail systems (Venmo, Alipay intra-net) are intermediated credits, not central-bank-money finality.
"Card networks carry the funds"	Visa/Mastercard are messaging and risk-management networks; actual interbank settlement happens through different rails (SWIFT / ACH / CHIPS).
"Stablecoins can replace SWIFT tomorrow"	Stablecoins solve messaging + settlement on one rail, but inherit the trust of their issuer and the KYC/AML of their on/off-ramps. Replacing SWIFT means replacing compliance infrastructure, not just rails.

The hardest problem in payments is not speed; it is finality + compliance + recourse. Rails that solve all three are rare.

Self-Check: Payment Rails

Attempt these before turning the page.

1. [Understand] Distinguish RTGS, DNS (deferred net settlement), and card-network settlement. Which provides true intraday finality?
2. [Apply] A correspondent bank holds $10M nostro at a US bank earning 4% annualised. With 24/7 settlement (FedNow + SEPA Instant) demanding 2x overnight liquidity buffer, what is the foregone yield per year on the extra $10M?
3. [Analyze] ISO 20022 mandated for SWIFT cross-border by Nov 2025. Identify two second-order consequences for regional banks lagging on migration.

Solutions hidden unless `\solutionstrue` is set before compiling.