E-Payment Systems and Cryptocurrency Technologies

Banking, Foreign Exchange
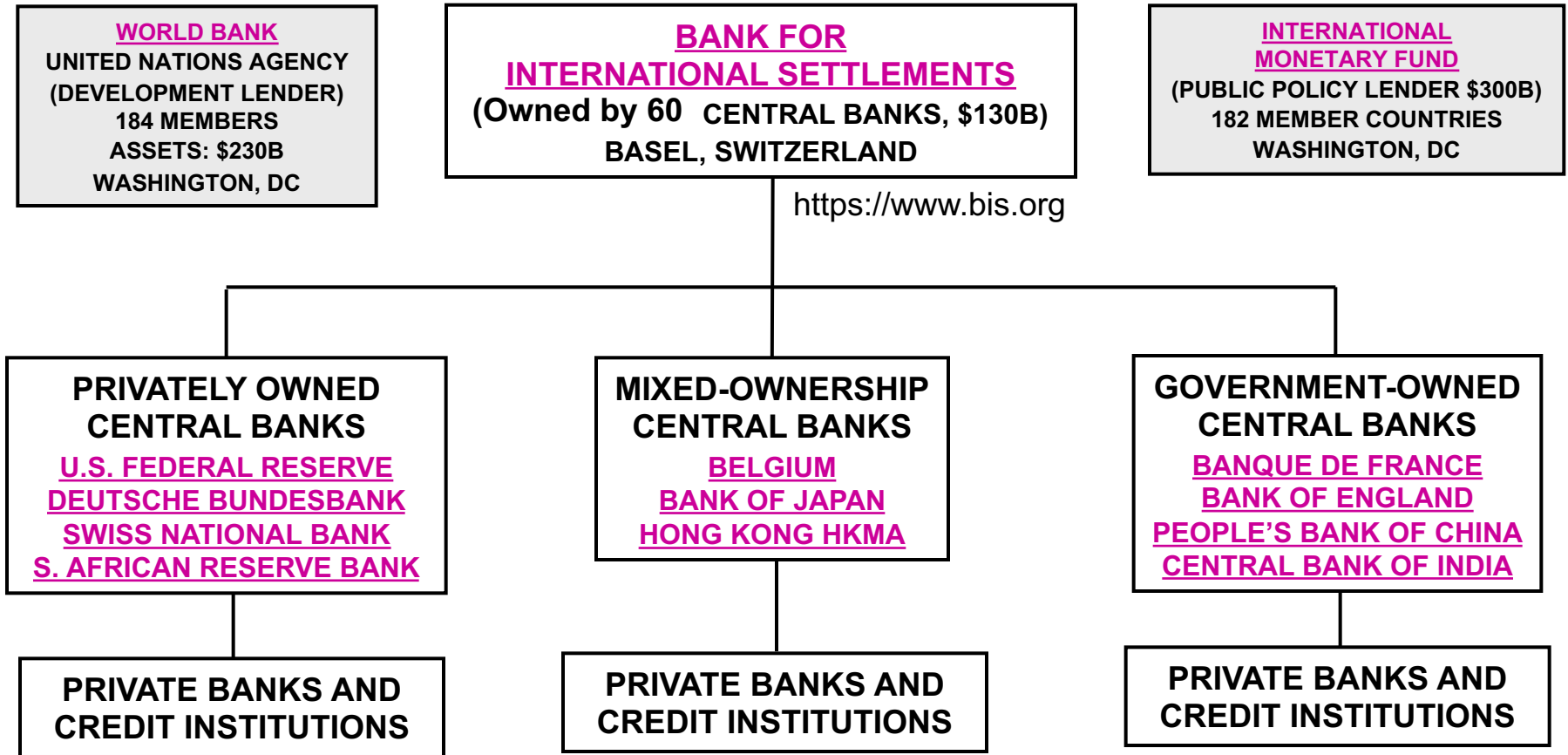+
Clearing and Settlement Systems

Acknowledgements

- The slides used in this lecture are mostly adapted from the following sources. The copyrights and contribution of the original authors are hereby acknowledged and recognized:

  - **The Electronic Payment Systems course by Prof. Michael Shamos, CMU**

  - "Financial Infrastructure in Hong Kong", HKMA Background Brief No. 4, 2006, https://www.legco.gov.hk/yr06-07/english/panels/fa/papers/facb1-657-4-e.pdf

  - Carol Coye Benson, Scott Loftesness, Russ Jones, Payments Systems in the U.S. - Third Edition: A Guide for the Payments Professional 3rd ed. Edition, Glenbrook Partners, 2017.

  - John Hill, Fintech and the Remaking of Financial Institutions, Academic Press 2018

  - Robert E. Litan and Martin Neil Baily, Editors, Moving Money: The Future of Consumer Payments, Brookings Institution Press, 2009.

  - Banking and Electronic Fund Transfer, OCDE, OCED, 1983.

  - Brett King, Breaking Banks -The Innovators, Rogues, and Strategists Rebooting Banking, Wiley, 2014.

Lecture Outline

- World banking system
- Central banks
- Money supply measures
- What banks do
- Foreign exchange
- US Banking and Payment Systems
- More Clearing and Settlement Systems

World Banking System

WORLD BANK	BANK FOR	INTERNATIONAL

WORLD BANK
UNITED NATIONS AGENCY
(DEVELOPMENT LENDER)
184 MEMBERS
ASSETS: $230B
WASHINGTON, DC

**BANK FOR
INTERNATIONAL SETTLEMENTS**
(Owned by 60 CENTRAL BANKS, $130B)
BASEL, SWITZERLAND

https://www.bis.org

**INTERNATIONAL
MONETARY FUND**
(PUBLIC POLICY LENDER $300B)
182 MEMBER COUNTRIES
WASHINGTON, DC

**PRIVATELY OWNED
CENTRAL BANKS**
U.S. FEDERAL RESERVE
DEUTSCHE BUNDESBANK
SWISS NATIONAL BANK
S. AFRICAN RESERVE BANK

**MIXED-OWNERSHIP
CENTRAL BANKS**
BELGIUM
BANK OF JAPAN
HONG KONG HKMA

**GOVERNMENT-OWNED
CENTRAL BANKS**
BANQUE DE FRANCE
BANK OF ENGLAND
PEOPLE'S BANK OF CHINA
CENTRAL BANK OF INDIA

**PRIVATE BANKS AND
CREDIT INSTITUTIONS**

**PRIVATE BANKS AND
CREDIT INSTITUTIONS**

**PRIVATE BANKS AND
CREDIT INSTITUTIONS**

SOURCE: TRANSACTION.NET

NOTE: Bank for International Settlements (BIS) has published the extremely informative
CMPI Red Book series, detailing the Payment, Clearing and Settlement systems in
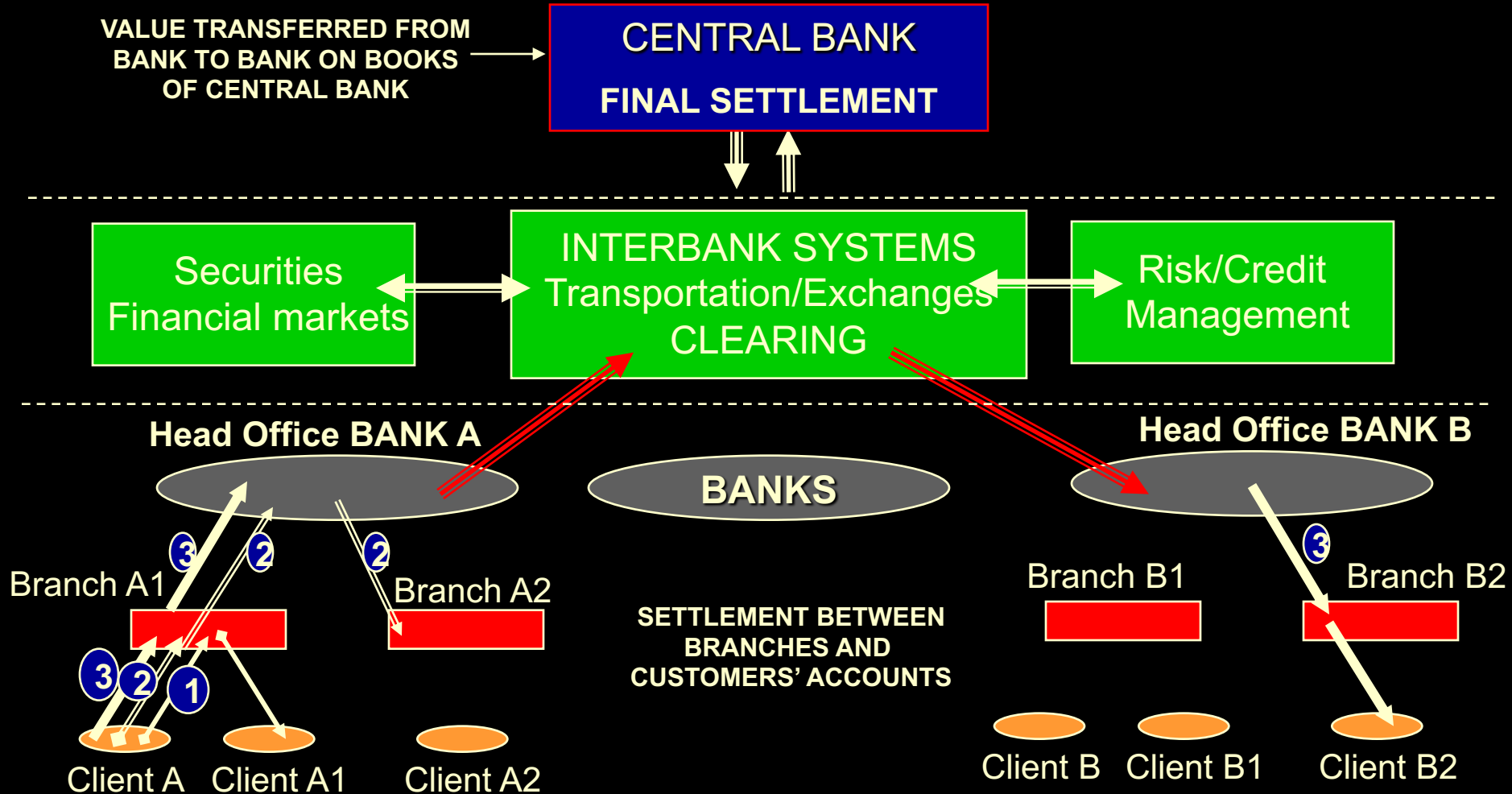various countries ! Freely available at: https://www.bis.org/list/cpmi/index.htm

Central Banks

■ Legal tender ("real money") is issued by central banks (and banks operating under their authority)
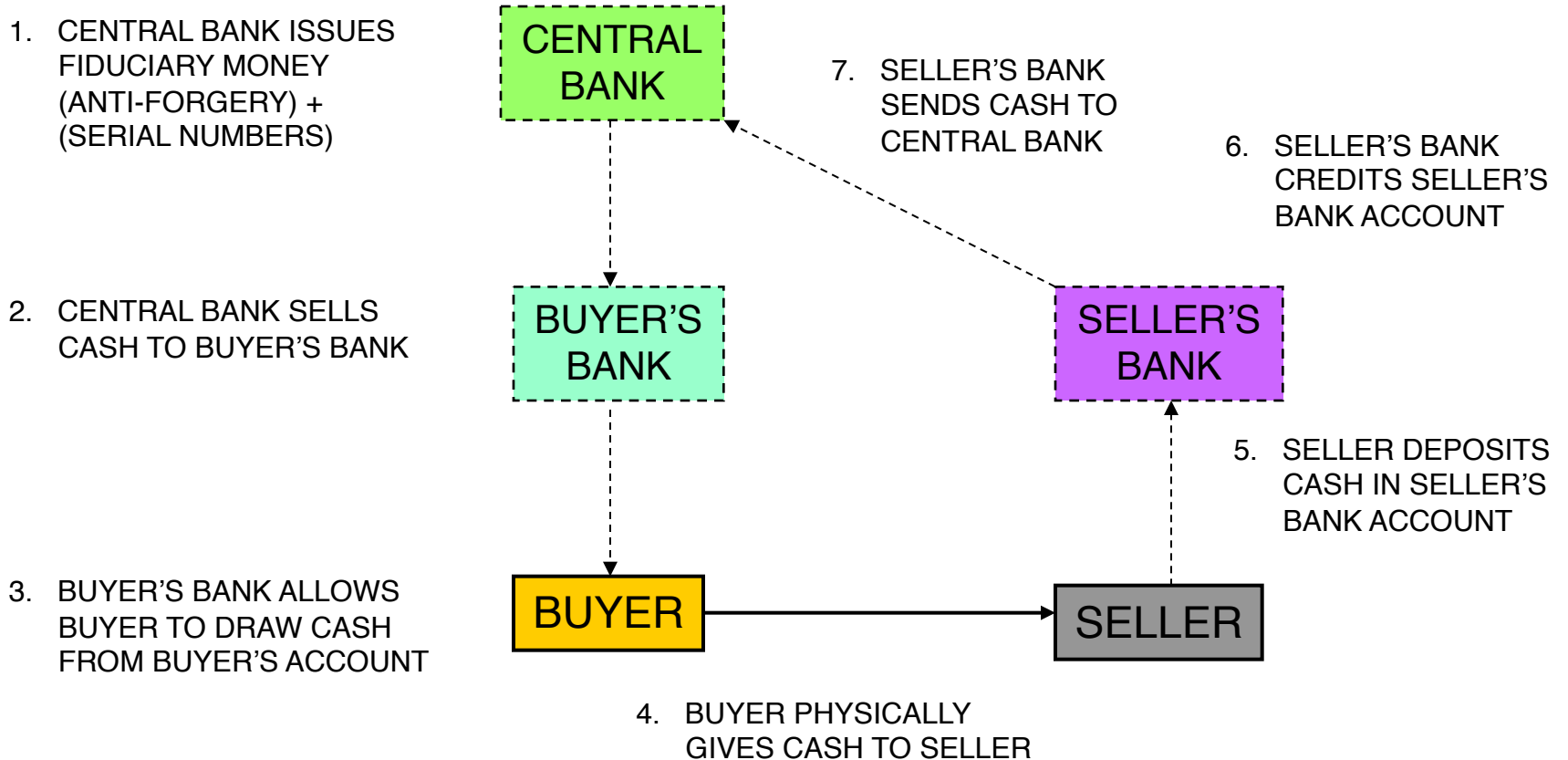
◆ U.S.: Federal Reserve Bank

■ Non-central banks cannot hold legal tender (except in cash form). (What form would it take?)

■ How do banks pay each other?

◆ Through accounts in the central bank (directly or indirectly)

Payment System Layers

VALUE TRANSFERRED FROM BANK TO BANK ON BOOKS OF CENTRAL BANK →

CENTRAL BANK

FINAL SETTLEMENT

Securities Financial markets

INTERBANK SYSTEMS Transportation/Exchanges CLEARING

Risk/Credit Management

Head Office BANK A

BANKS

Head Office BANK B

③ ② ②

Branch A1

Branch A2

SETTLEMENT BETWEEN BRANCHES AND CUSTOMERS' ACCOUNTS

Branch B1

③

Branch B2

③ ② ①

Client A   Client A1   Client A2

Client B   Client B1   Client B2

Cash Transaction

1. CENTRAL BANK ISSUES FIDUCIARY MONEY (ANTI-FORGERY) + (SERIAL NUMBERS)

CENTRAL BANK

7. SELLER'S BANK SENDS CASH TO CENTRAL BANK

6. SELLER'S BANK CREDITS SELLER'S BANK ACCOUNT

2. CENTRAL BANK SELLS CASH TO BUYER'S BANK

BUYER'S BANK

SELLER'S BANK

5. SELLER DEPOSITS CASH IN SELLER'S BANK ACCOUNT

3. BUYER'S BANK ALLOWS BUYER TO DRAW CASH FROM BUYER'S ACCOUNT

BUYER

SELLER

4. BUYER PHYSICALLY GIVES CASH TO SELLER

Money Supply in US

Money Supply in US - Components

M2 in Details

May 2017 ($billions, seasonally adjusted)

Savings Deposits, $8,962

Small Denomination Time Deposits, $349

Retail Money Market Funds, $679

Currency and Coins, $1,469

Demand Deposits, $1,465

Other Checkable Deposits, $679

Traveler's Checks, $2

M1 components of M2

$0 $1,000 $2,000 $3,000 $4,000 $5,000 $6,000 $7,000 $8,000 $9,000 $10,000

Source: Federal Reserve Board 7/6/17 data release
Note: Components may not add to totals due to rounding
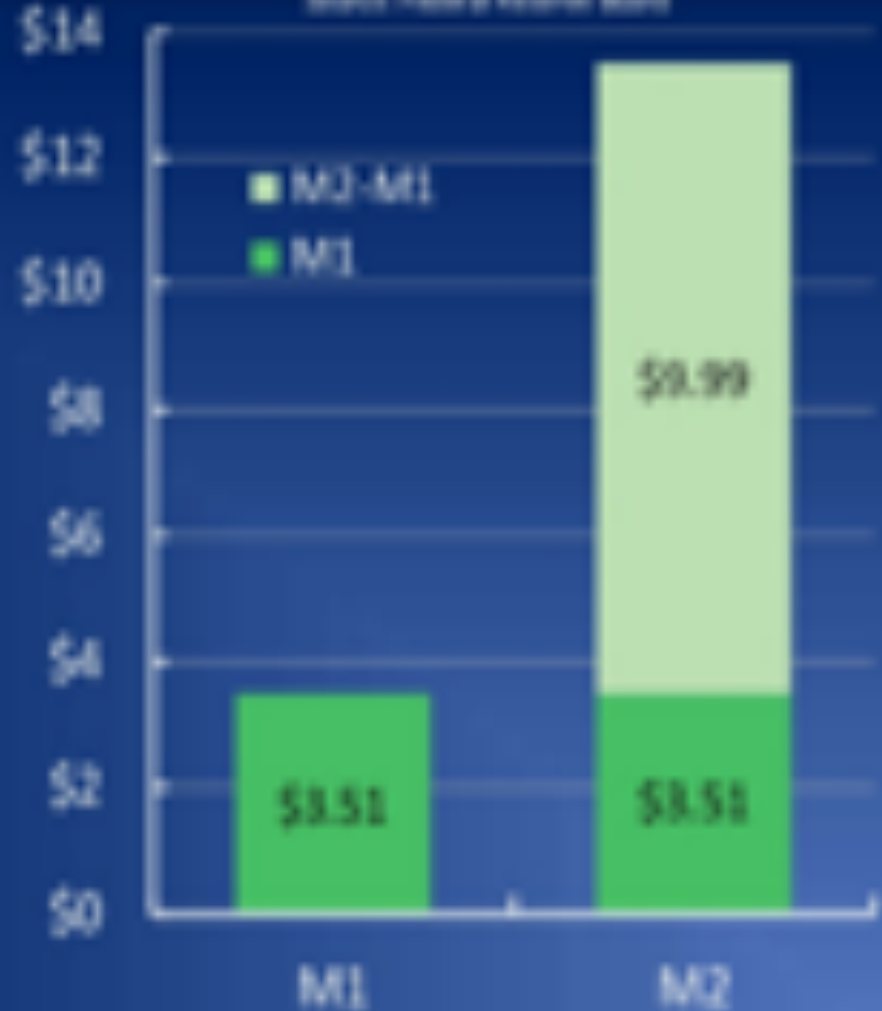
Money Supply

- Money supply of US (in USD)

  - M0 (currency = coins & notes) 3.3 Trillion (Nov. 2019) vs. 661B in Nov. 2003.

  - M1 (spendable now) 4.0 Trillion (Nov. 2019) vs. 1.28T (Nov 2003) (liquid = M0 + non-interest deposits + travelers checks)

  - M1 IS MONEY AVAILABLE FOR PAYMENTS

  - M2 (M1+ time deposits + bank CDs) 15.3T (Nov 2019) vs. 6.07T (Nov 2003)

  - M3 (M2 + large time deposits + institutional money funds) 8.86T (in Nov 2003) ; US Fedral Reserve no longer uses M3

Function of Banks

- Central banks:
  - Issue fiduciary money (both token and notational)
- All other (non-central) banks:
  - Issue notational scriptural money (bank accounts)
    - Not fiduciary ("real money"), not token
- Non-central banks
  - Move notational money
  - Accept deposits (loans from depositors)
  - Loan deposits to others (borrowers)

What is a Bank Account?

- Notational representation of a loan to the bank from a depositor
- Once the depositor puts money in his account, it becomes <u>the bank's money</u>, not the depositor's
- When the bank deposits its money in the central bank, it becomes fiduciary (real) money
- The bank then <u>owes</u> the depositor real money
- Effect of deposit: bank ends up with more real money

I HAVE $1000 → I DEPOSIT $200 IN THE BANK → I HAVE $800. BANK OWES ME $200 (MY "ACCOUNT") → BANK DEPOSITS $200 IN CENTRAL BANK → BANK HAS $200 MORE MONEY NOW

MY ASSETS:
  $1000 CASH

MY ASSETS:
  $800 CASH
  +$200 OWED BY BANK

BANK'S ASSETS:
  +$200 REAL MONEY
  - $200 DEBT
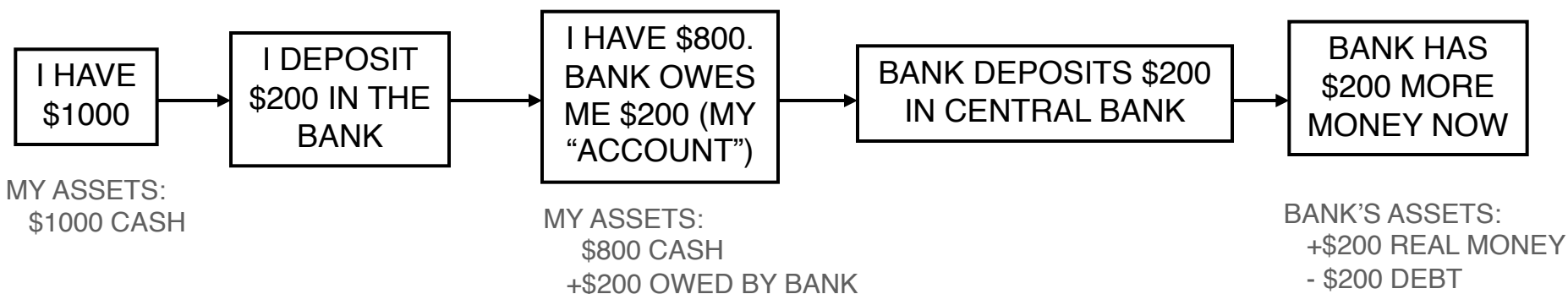
Benefit of a Bank Deposit

■ Bank can

  ◆ loan the money (more than was deposited!)

  ◆ invest the money

  ◆ move the money, e.g. make <u>payments</u>

  ◆ buy foreign currency with the money

■ Reserve Ratio

  ◆ Fraction of deposits the bank must keep in the central bank

  ◆ If the Reserve Ratio (RR) is 25%, then for a $1000 deposit, the bank can lend out $3000, so total notational money in the society = $4000!

  Let D be the customer's deposit into the bank

  Total amount the Bank can lend out after fulfilling the RR:

  $$= D*(1-RR) + D*(1-RR)*(1-RR) + D * (1-RR)^3 + \ldots$$

  $$= D*(1-RR) / [1-(1-RR)] = D*(1-RR)/RR$$

Foreign Exchange

- Currency = token fiduciary money of a central bank
- Every bank account is denominated in one currency
- Most banks allow accounts in only one currency
- All currencies have three-letter ISO currency codes:
  - USD (U.S. dollar)   JPY (Japan yen)
  - GBP (Great Britain pound)   CHF (Swiss franc)
  - HKD (Hong Kong dollar)   EUR (Euro)
  - CNY (Chinese Yuan ; commonly called Renminbi)
- Usually, the first two letters indicate the country; third letter is the first letter of the currency name
- Foreign exchange is a barter transaction
  - To buy GBP for USD, buyer has to find someone with GBP who wants USD

Foreign Exchange

- Every bank must have an account at the central bank (or with another bank that has a central account)
- The account is (usually) denominated in that country's currency and is used to settle obligations in that currency
  - Hong Kong is an exception. It has 4 systems (RTGS: Real-Time Gross Settlement systems) for transacting in HKD, USD, CNY and EUR.
- A foreign exchange transaction requires <u>two settlements</u>, one in each currency
- Therefore, <u>two countries' central banks</u> (or settlement systems) are involved (except in HK, more later)

Foreign Exchange Example

- Buyer in the US wants to pay an invoice in GBP from Seller in the UK

- Buyer needs GBP. Where does he get them? Where does he put them? This is done through banks.

- Bank B (buyer) in the U.S. buys 1 million GBP for 1.78 million USD from Bank S (seller) in the UK

- Bank B must have an account denominated in GBP somewhere, probably at Bank C in the UK

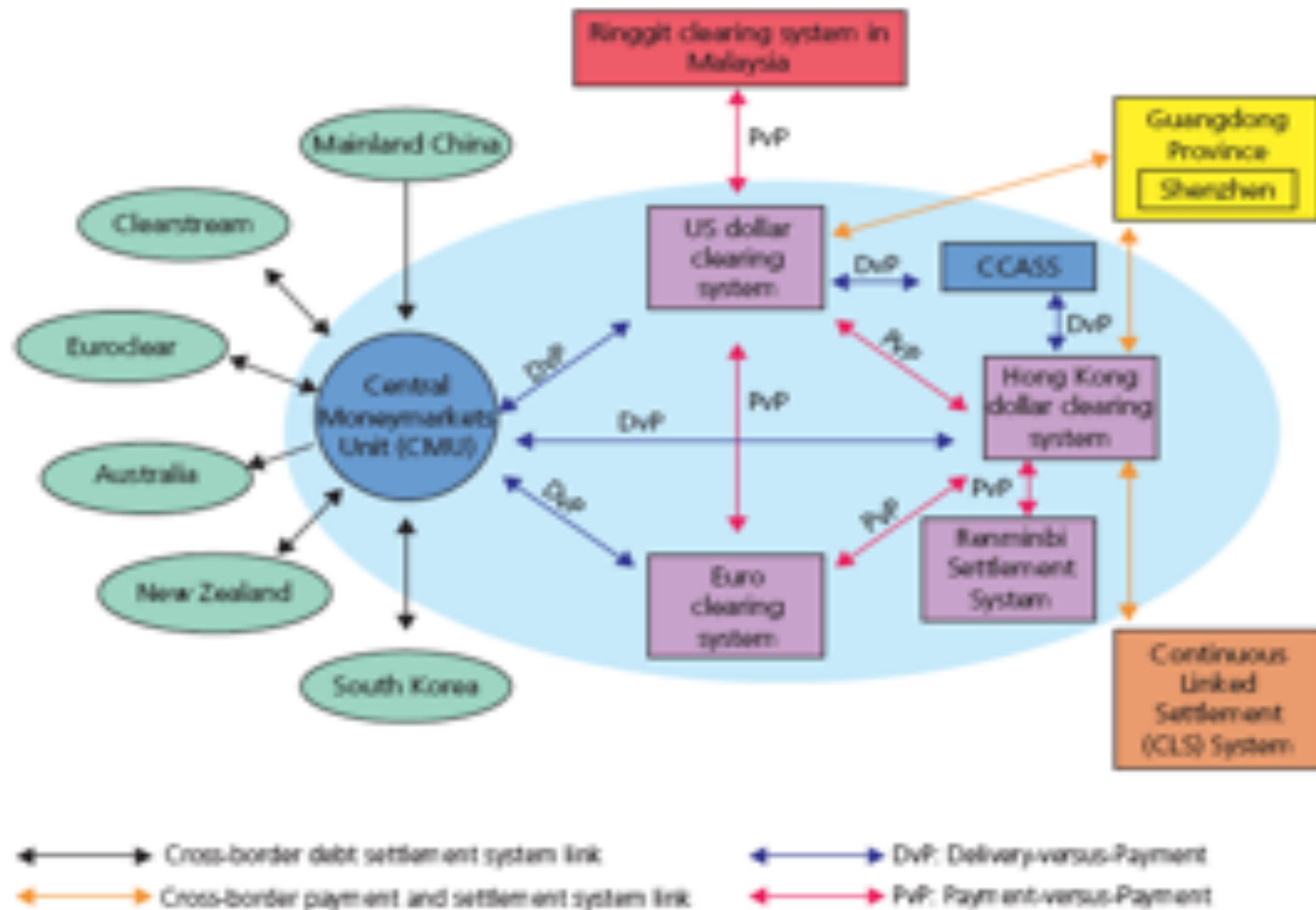- Bank S must have an account denominated in USD somewhere, probably at Bank T in the US

Foreign Exchange Example

BANK T (US)

BANK S
USD ACCOUNT

US BANKS

(NOSTRO ACCOUNT)

BANK S (UK)
WILLING TO SELL
1 MILLION GBP
FOR USD

BANK B (US)
WANTS TO BUY
1 MILLION GBP
FOR USD

(NOSTRO ACCOUNT)

BANK C (UK)

BANK B
GBP ACCOUNT

UK BANKS

**US FEDERAL
RESERVE BANK**

BANK B USD ACCOUNT

BANK T USD ACCOUNT

**THE BANK
OF ENGLAND**

BANK S GBP ACCOUNT

BANK C GBP ACCOUNT

CENTRAL
BANKS

SETTLEMENT ONE:
 BANK B PAYS 1.78
 MILLION USD TO BANK T

 SELLER S NOW HAS 1.78
 MILLION USD IN BANK T

SETTLEMENT TWO:
 BANK S TRANSFERS
 1 MILLION GBP TO BANK C

 BUYER B NOW HAS 1
 MILLION GBP IN BANK C

Foreign Exchange in Hong Kong

- A bank's sight deposit account is (usually) denominated in that country's currency and is used to settle obligations in that currency

- Hong Kong is an exception. HK has 4 systems, namely the 4 Real-Time Gross Settlement systems (RTGS) for transacting in HKD, USD, CNY and EUR.

  - Interbank HKD settlements via a bank's account with HKMA
  - HSBC serves as the settlement institution for USD
  - Standard Chartered Bank as the settlement institution for EUR
  - Bank of China as the clearing bank for CNY
    - The RMB RTGS can be considered as an extension of the CNAPS (China's National Advanced Payment System) but governed by Hong Kong laws

- Hong Kong Interbank Clearing Limited (HKICL) is the *operator* of all of these 4 RTGS systems

    - https://www.hkma.gov.hk/eng/key-functions/international-financial-centre/financial-market-infrastructure/payment-systems/
    - https://www.hkma.gov.hk/media/eng/publication-and-research/quarterly-bulletin/qb9508/fa01.pdf

Overview of Financial Infrastructure in Hong Kong (circa 2006)

Hong Kong's Multi-currency Payment and Settlement Infrastructure (since 2012)

BI-RTGS = Indonesia payment system
CCASS = Central Clearing and Settlement System for stock
CDFCPS = China's Domestic Foreign Currency Payment System
CLS = Continuous Linked Settlement
CMU = Central MoneyMarkets Unit
CNAPS = China National Advanced Payment System
RENTAS = Malaysia payment system

— Delivery versus Payment (DVP)
— Payment versus Payment (PVP)
— System linkages
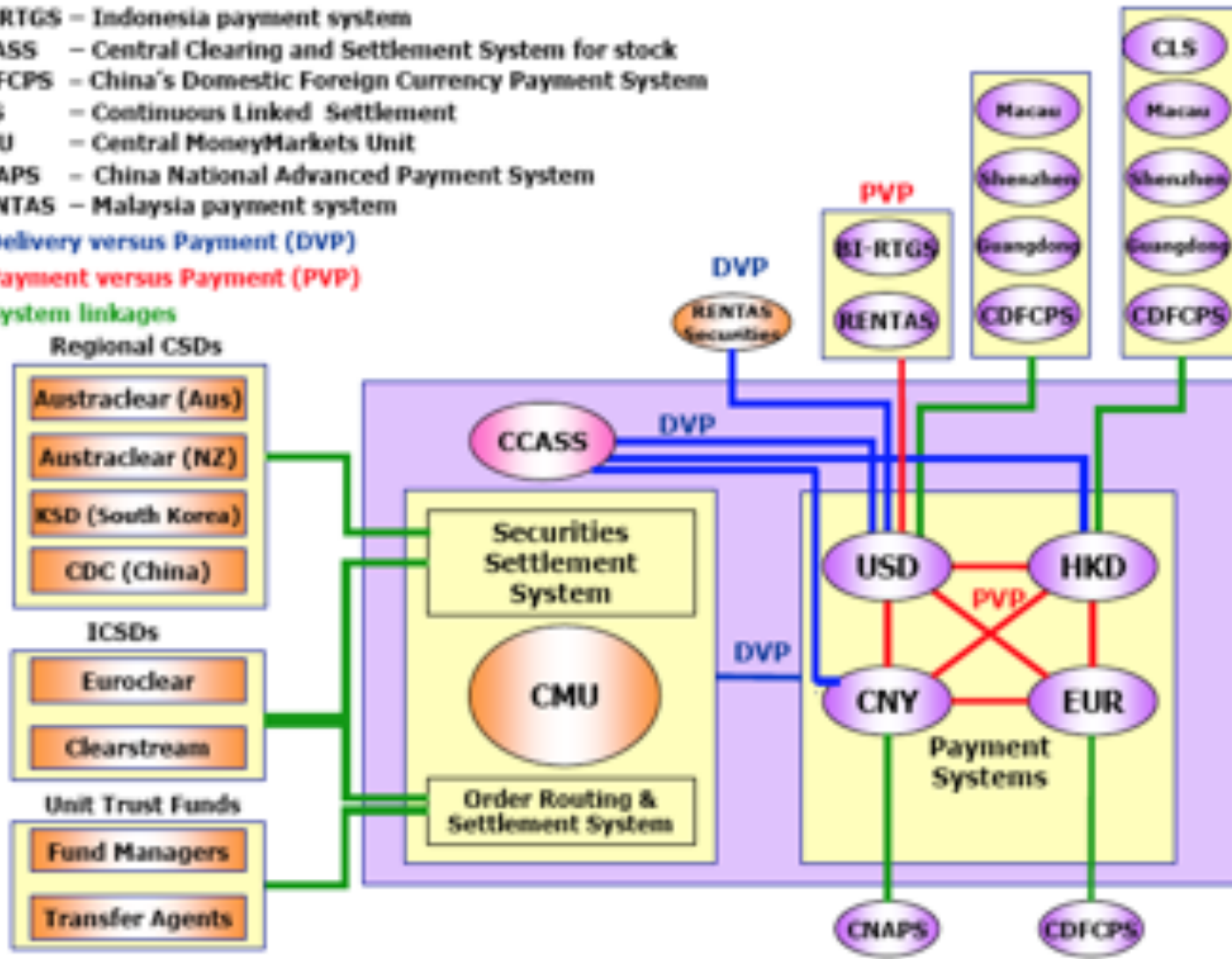
Clearance v. Settlement

- **Messaging**
  - Transmission of payment orders
- **Clearance**
  - Determining the net effect of multiple payment orders
  - How much does each party owe or is owed?
- **Settlement**
  - Actual payment, *often (NOT ALWAYS)* involving a central bank
- **Foreign exchange requires two settlements**
  - Exchange HKD (HK dollars) to JPY (Japanese ¥) requires settlement in both HKD <u>and</u> JPY

Gross v. Net Settlement Systems

- Gross settlement system: every transaction is processed separately (usually immediately)
  Example: cash purchase, large-value bank transfers
- Problem: transaction overhead, network load

- Net settlement system: transactions are batched
  Example: credit cards
  - Merchant is paid once per day, not for each sale
  - Customer is billed once per month
- Problem: Delay. <u>Time is the enemy of money</u>.
  There is also higher risk of bulk, delayed net settlements !
  - Alternative (later in the notes): Payment-vs-Payment PvP real-time simultaneous settlements in 2 currencies as in HK to overcome time-zone difference/ delayed settlement risks

Payment Graphs
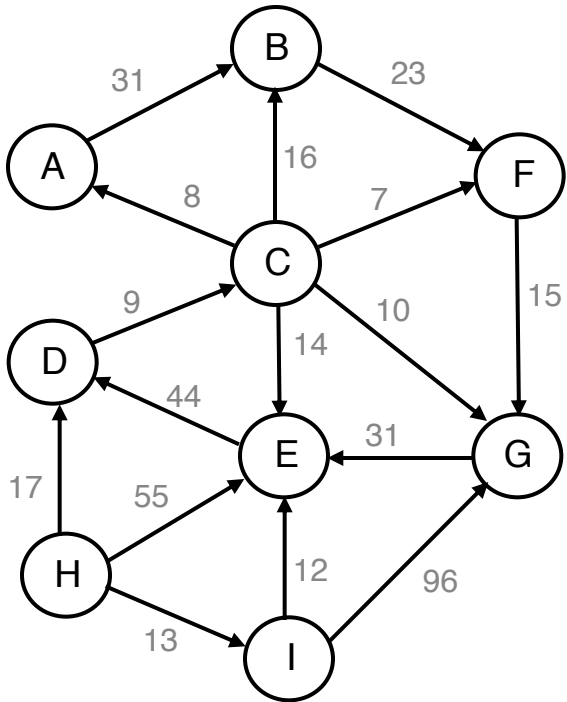
WITH N PARTIES, NUMBER OF
POSSIBLE DEBTS IS N(N-1)/2
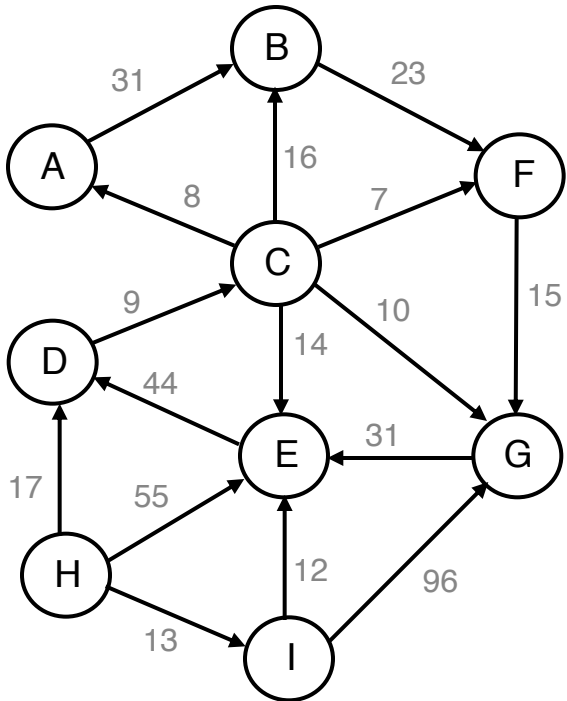
10,000 BANKS, 50 MILLION PAYMENTS
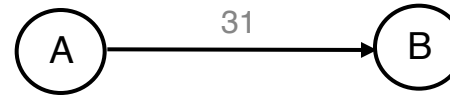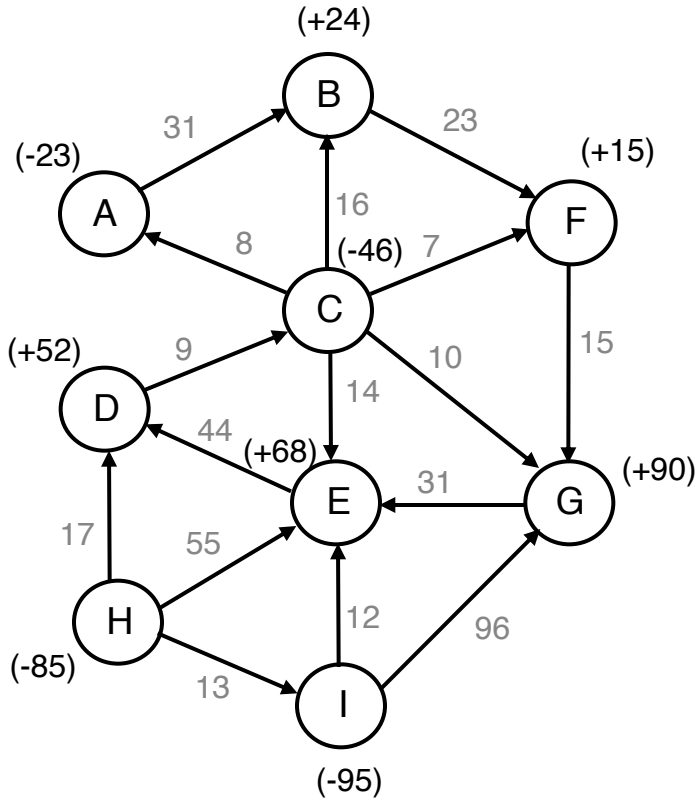
"A OWES B $31"

"A HAS $49; B HAS $16;
A OWES B $31"

"A HAS $49; B HAS $16;
A OWES B $31;
A IS OWED NET $15;
B OWES NET $12"
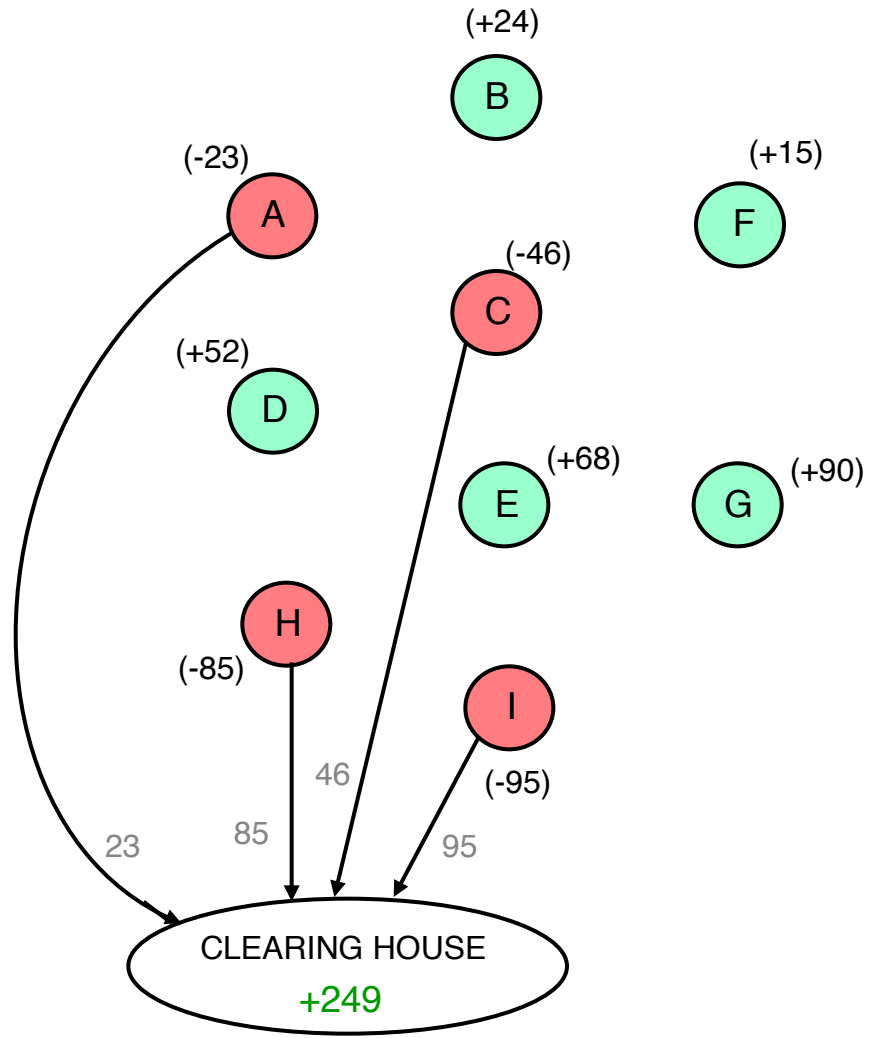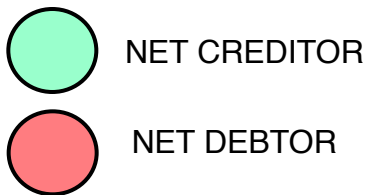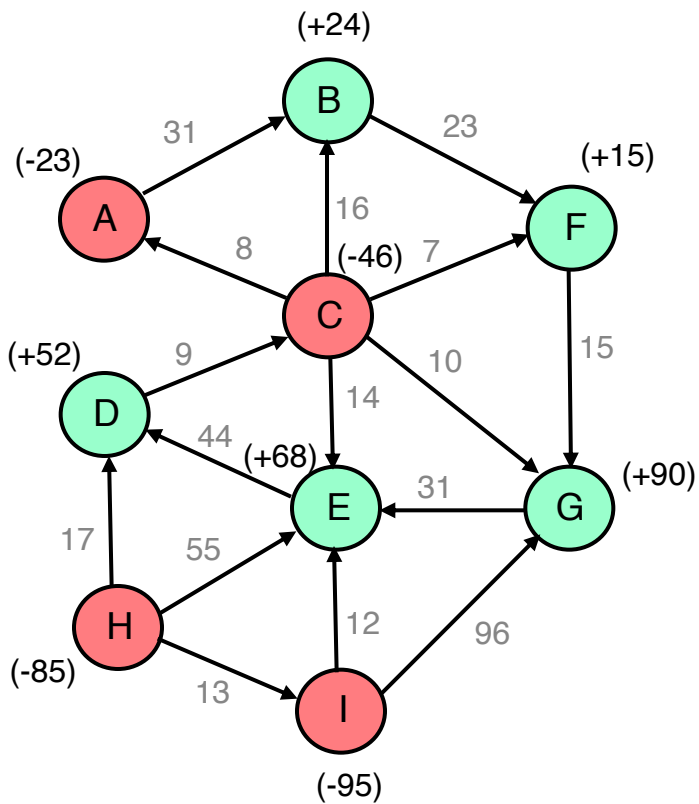
Gross Settlement

- Each debt is settled individually

- # of payments = # of debts

- Here, 16 payments required

- Collection is a problem (failure to pay)

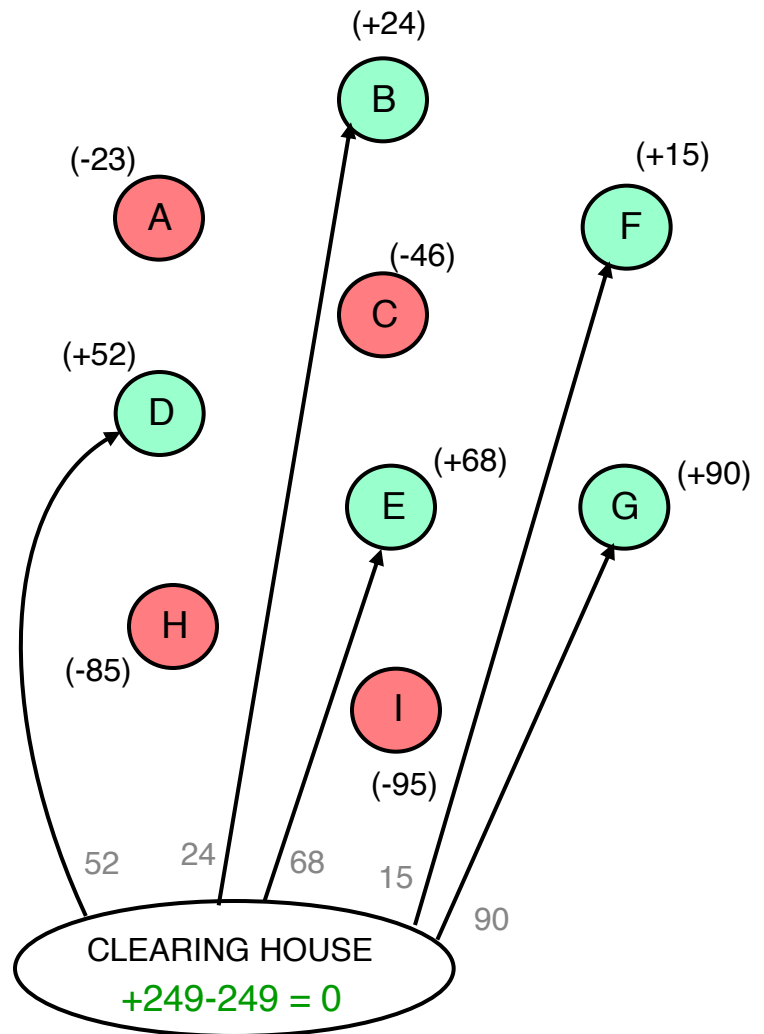- RTGS = "real-time gross settlement," immediate payment
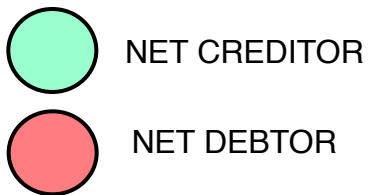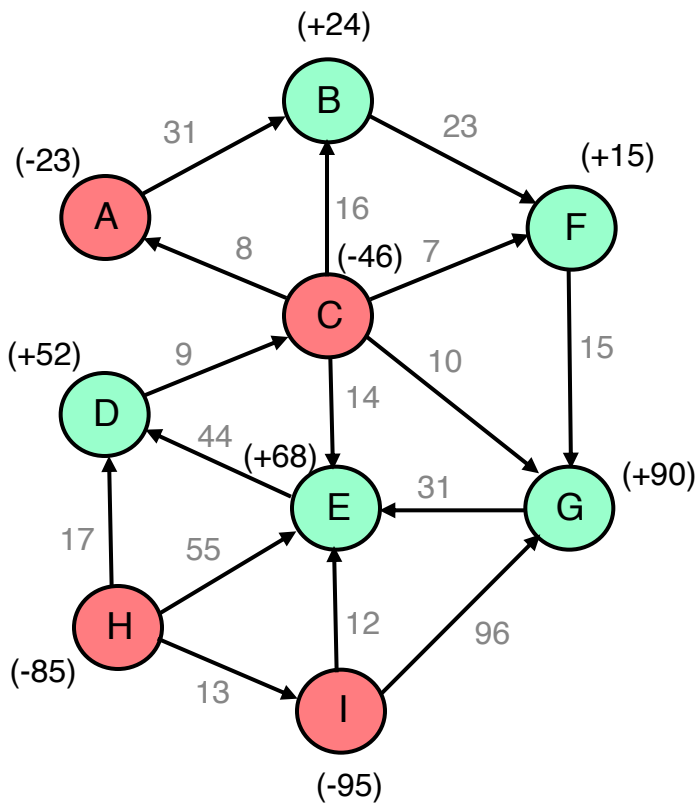
Net Settlement

- Compute net amount owed or owing for each party
- Net debtors make one payment to the "clearing house"
- Net creditors receive one payment from the clearing house
- # of payments = # of parties
- 10,000 banks = 10,000 payments, not 50 million

Net Settlement

NET CREDITOR

NET DEBTOR

CLEARING HOUSE
+249

Net Settlement

Net v. Gross Settlement

- Net settlement requires "clearing"
  - Determining the net amounts owed or owing
- Need a separate clearing house
- Introduces delay (for clearing)
- Reduces counterparty risk
- Used for large numbers of small payments, e.g. cheques, credit cards

- Gross settlement can be instantaneous (< 1 minute)
- Gross settlement involves a large number of payments; used for large transactions, e.g. interbank transfers

Problems/ Risks in Net Settlement Systems

- Delay. <u>Time is the enemy of money</u>
  - Time-zone Difference worsens the situation if Business Operating Hours is not 24-hr around the clock !
  - There is also higher risk of BULK, delayed Net settlements !

- Painful Lesson Learnt: The Herstatt Foreign Exchange Risk

- Alternative: Payment-vs-Payment PvP real-time simultaneous settlements in 2 currencies as in HK to overcome time-zone difference/ delayed settlement risks

Herstatt Foreign Exchange Risk

- Bankhaus Herstatt, Germany, June 26, 1974
- In FOREX trade, received DEM for USD in Germany that day. Value: USD 621 million
- Went bankrupt; lost its banking license; ordered into liquidation <u>after</u> the close of the German interbank payment system at 3:30 p.m. (9:30 a.m. in NY)
- Its correspondent bank in New York refused to pay out USD at 10:30 a.m.
- The banks that paid DEM never received USD
- Effect on banking system was <u>25 times</u> the amount of the loss
- This is the "Herstatt risk" – that only one leg of a foreign exchange transaction will settle, causing Cascade Effect
  - A more Recent Lesson: The Collapse of Lehman Brothers a US-based Bank and Global Financial Service firm in Sept 2008 which triggered Financial Tsunami world-wide

Overview of Financial Infrastructure in Hong Kong

Source: https://www.legco.gov.hk/yr06-07/english/panels/fa/papers/facb1-657-4-e.pdf
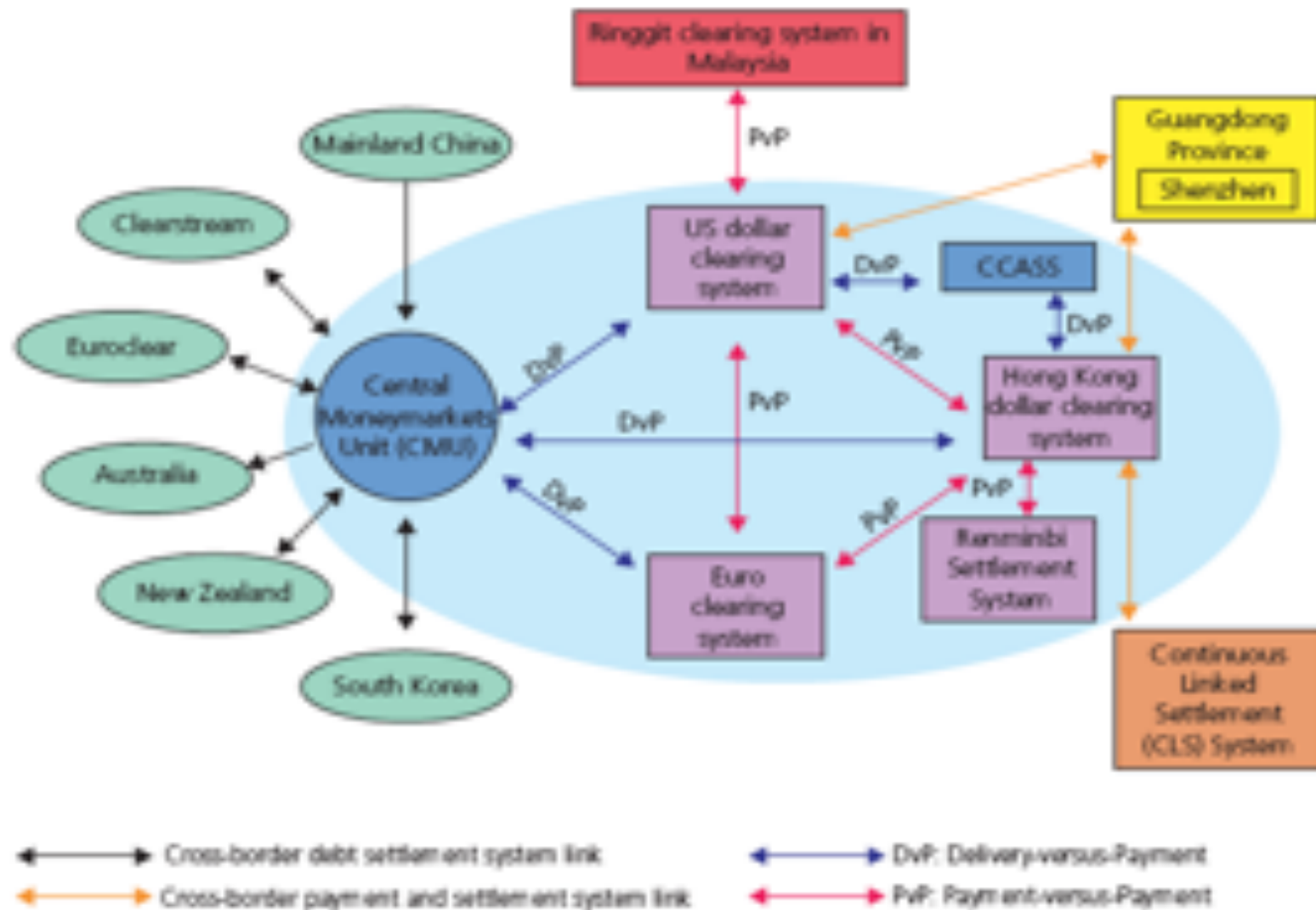
Hong Kong Payment vs. Payment (PvP)

Eliminates Herstatt Risk

Bank X selling HKD to Bank Y for USD

CCPMP = CROSS-CURRENCY
PAYMENT MATCHING PROCESSOR
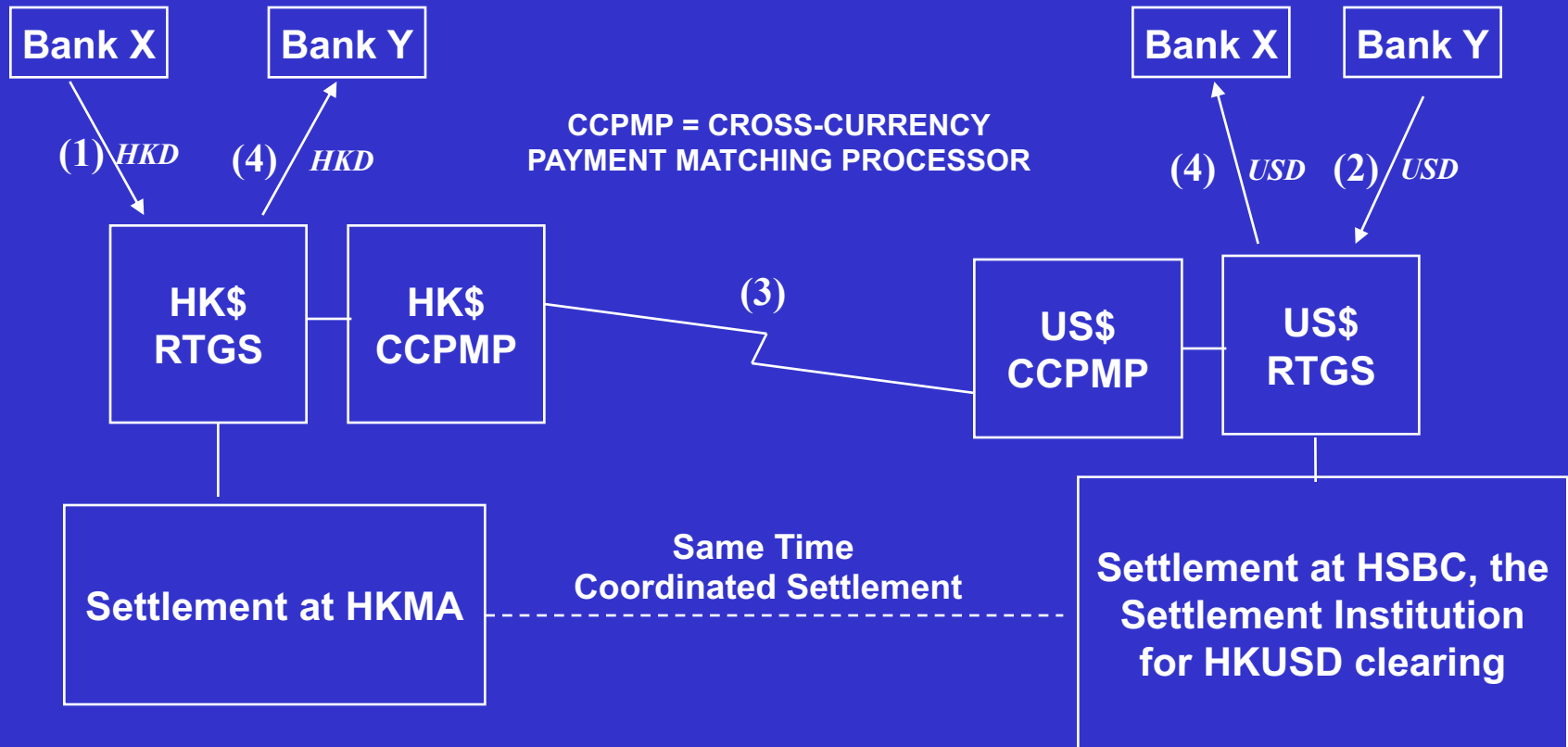
(1) HK$ payment from Bank X withheld by HKMA awaiting confirmation from US$ RTGS system.
(2) US$ payment from Bank Y withheld by HSBC awaiting confirmation from HK$ RTGS system.
(3) Message exchange uses the cross currency payment matching processor (CCPMP).
(4) Once matching is done - US$ released to Bank X' HK$ released to Bank Y

US Banking and Payment Systems

Federal Reserve System

Interdistrict Settlement Fund
(Washington DC)

INFO

+ branches (Cleveland Fed has a branch in Pittsburgh)

Regional Automated Clearing House (ACH) Networks in the US

Other States/Territories

Alaska

Hawaii

Guam

Puerto Rico

U.S. Virgin Islands
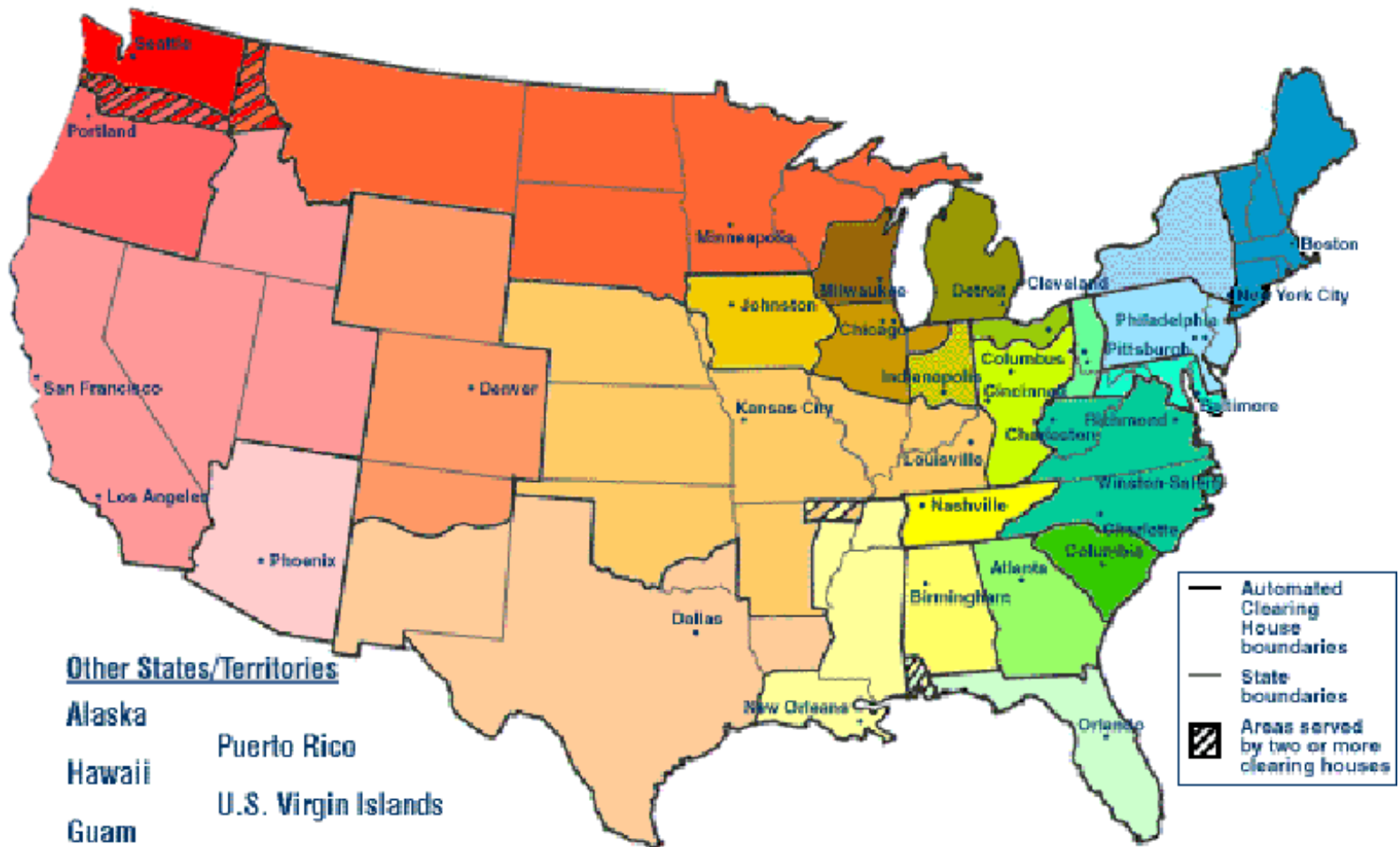
More details on ACH later …

Fedwire

- Real-time gross settlement system of the Federal Reserve
- Used by any institution that has an account at the Federal Reserve
- Used mainly for large transfers (average: $3.5M)
- On-line connection (7800 institutions, 99% of transfers)
  - Direct connection
  - Computer dialup
- Off-line connection (1700 institutions, 1% of transfers)
  - Telephone instructions with codeword
- FedLine access from PCs
- Some services over the Web (not funds transfer yet)

Fedwire Participants

- Depository institutions

- Agencies and branches of foreign banks

- Member banks of the Federal Reserve System

- U.S. Treasury and authorized agencies

- Foreign central banks, foreign monetary authorities, foreign governments, and certain international organizations; and

- Any other entities authorized by a Reserve Bank

SOURCE: FED

Fedwire

- 10,000 participants
- 108 million Fedwire transfers/yr, 300,000 per day
  - Value $380T (11 times the World Economic Product)
  - New York Fed: 40 million transfers, $209T
- "Instantaneous" (within minutes) irrevocable settlement
- Payment guaranteed by Fed
- Operates 18 hours/day on business days
- No minimum dollar amount
- Daylight overdrafts permitted (intraday peak: $70B)
  - Fee charged if not collateralized ($6.94 per million)

Daylight Overdrafts

- An overdraft that must be repaid by the close of business the <u>same day</u>

- U.S Federal Reserve allows daylight overdrafts

- Hong Kong does not ; Banks need to keep Liquidity throughout the day of trading ; can borrow from HKMA

U.S. Federal Reserve Daylight Overdraft History
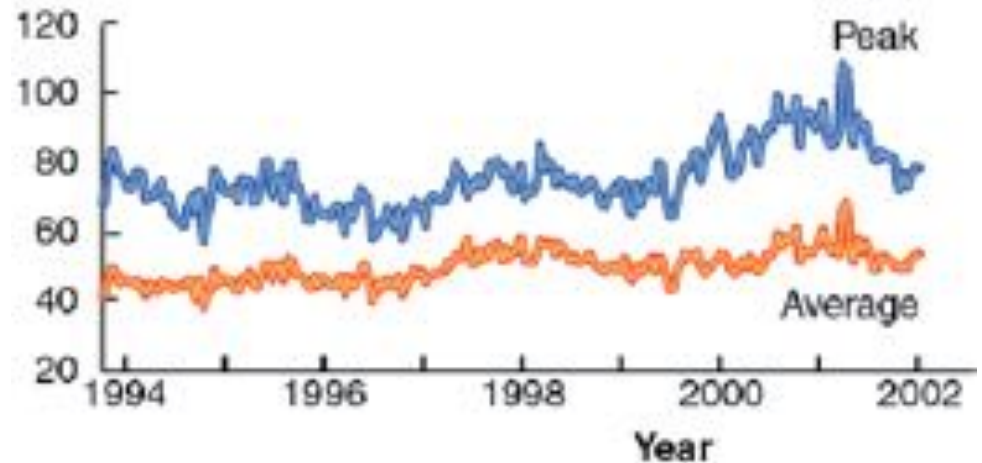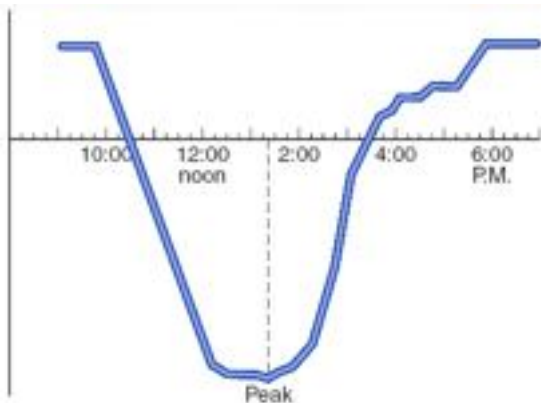
SOURCE: FEDERAL RESERVE

How Fedwire Works

EVERGEEN BANK
(SEATTLE)

PNC WANTS TO TRANSFER
$1M TO EVERGREEN BANK

PNC BANK
(PITTSBURGH)

9. SEATTLE BRANCH NOTIFIES
EVERGREEN. PAYMENT IS
NOW IRREVOCABLE.

1. PNC SENDS TRANSFER ORDER
TO PITTSBURGH BRANCH OF
CLEVELAND FED

SAN FRANCISCO FED
(SEATTLE BRANCH)

CLEVELAND FED
(PITTSBURGH BRANCH)

8. SF FED NOTIFIES
SEATTLE BRANCH

2. PITTSBURGH BRANCH SENDS
ORDER TO CLEVELAND FED

6. ISF NOTIFIES
SF FED

INTERDISTRICT SETTLEMENT FUND
ATLANTA FED
BOSTON FED
CLEVELAND FED
. . .
SAN FRANCISCO FED

4. CLEVELAND
SENDS
ORDER
TO ISF

SAN FRANCISCO FED
EVERGREEN BANK
. . .
WELLS FARGO
WESTERN BANK

CLEVELAND FED
DOLLAR BANK
MELLON BANK
. . .
PNC BANK

7. SF FED ADDS $1M TO
EVERGEEN ACCOUNT

5. ISF SUBTRACTS $1M FROM
CLEVELAND, ADDS $1M TO SF

3. CLEVELAND FED
SUBTRACTS $1M
FROM PNC ACCOUNT

Fedwire Fees

Service	Billing Code	Fee
Volume-Based Pricing Fees (Origination and Receipts)		
Per Transfer for the First 2,500 Transfers per Month	10001/10005	$0.33
Per Transfer for Additional Transfers up to 80,000 per Month	10002/10006	$0.24
Per Transfer for Every Transaction over 80,000 per Month	10003/10007	$0.16*
Surcharge		
Off-line Transfer Originated or Received	10011	$15.00
Telephone Notification	10015	$15.00

*Effe...

Funds Transfer System
Pricing History 1995-2001

	1995	1996	1997	1998	1999 *	2000 *	2001 *
	$0.53	$0.50	$0.45	$0.40	$0.2554	$0.2223	$0.2205
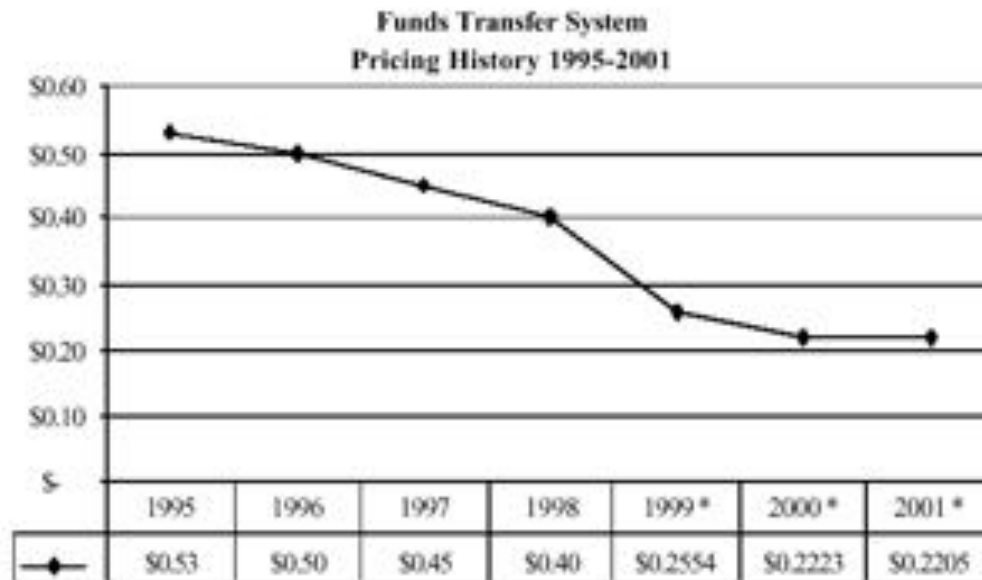
SOURCE: FEDERAL RESERVE

Federal Reserve Check Processing

- The Fed also performs ACH and paper check processing functions
- 46 regional check processing centers
- Interdistrict Transportation System (ITS) an airline for physical movement of checks
- ACH charges (Oct. 1, 2001):
    - $5.00 per computer file
    - $0.004 - $0.0055 per item (about 1/2 cent)

CHIPS

- Clearing House Interbank Payment System
  - Clearing and settlement for USD foreign exchange
  - Subsidiary of the New York Clearing House
- Handles 95% of all U.S. dollar foreign exchange payments
- 47 participants only (mostly banks, and other financial institutions, US and other countries), as of 2020
  - (vs. 9000+ members of Fedwire)
- Settles through NY Federal Reserve
- Average 250,000 transactions / day   (peak: 457K)
- Average USD 1.2T / day   (peak: 2.2T)
- Average transaction value: USD 5,180,000
- Annual volume: USD 287T
- Down about 20 minutes per year

CHIPS Participants

0958	ABN-AMRO Bank N.V.		0103	Deutsche Bank Trust Co Americas
0159	American Express Bank Ltd.		0830	Dresdner Bank AG
0572	Arab Bank PLC		0285	Wachovia Bank, N.A. - Charlotte
0861	Banca di Roma		0032	Fleet National Bank
0981	Banca Nazionale Del Lavoro		0776	Harris Trust and Savings Bank
0184	Banco Bilbao Vizcaya, S.A.		0108	HSBC Bank USA
0855	Banco de la Nacion Argentina		0908	International Commercial Bank of China
0355	Banco do Brasil S.A.		0531	Banca Intesa S.p.A.
0869	Bangkok Bank Public Co. Ltd.		0976	Israel Discount Bank of New York
0886	Bank Hapoalim B.M.		0002	JP Morgan Chase
0279	Bank Leumi USA		0824	KBC Bank N.V.
0959	Bank of America, N.A.		0555	M&T Bank
0326	Bank of China		0862	The Mitsubishi Trust and Banking Corp.
1262	Bank of Communications		0430	Mizuho Corporate Bank Ltd - NY
0001	The Bank of New York		0772	National Australia Bank
0253	Bank of Nova Scotia		0217	The National Bank of Kuwait SAK
0963	Bank of Tokyo-Mitsubishi, Ltd.		0112	The Northern Trust Company
0979	Bank One, National Association		0422	Societe Generale
0257	Barclays Bank PLC		0256	Standard Chartered Bank
0768	BNP Paribas New York		0914	State Bank of India
0480	Brown Brothers Harriman & Co.		0487	State Street Bank and Trust Co.
0008	Citibank, N.A.		0967	Sumitomo Mitsui Banking Corporation
0804	Commerzbank AG		0799	UBS AG
0865	Credit Industriel et Commercial		0982	UFJ Bank Limited
0807	Credit Lyonnais		0505	Union Bank of California, N.A.
0371	Danske Bank		0509	Wachovia Bank, N.A. - New York
0378	Deutsche Bank AG		0407	Wells Fargo Bank Minnesota, N.A.

CHIPS Operation

- London Bank L has an account in a NY Bank A
- Wants to transfer $1M to the account of Bank J in NY Bank B (A and B are on CHIPS)
- Bank L sends Bank A a SWIFT message
- Bank A verifies the message, enters it into CHIPS (Bank A has the $1M; doesn't rely on L's credit)
- CHIPS verifies that the transaction is within A's debit limit and the B-A bilateral limit; otherwise rejects
- CHIPS notifies Bank B that $1M is being deposited from Bank L through Bank A for Bank J
- Bank B notifies Bank J that $1M has been added to its account

CHIPS Operation

- CHIPS closes at 4:30 p.m. NY time
- Each settling bank gets a settlement report showing net amount owed or owing
- Settling banks have until 5:30 to challenge the total or must pay into the CHIPS account at the NY Federal Reserve by Fedwire (US RTGS)
- Banks with net credit positions are paid by 5:45
- All payment orders are final and irrevocable
- Fedwire is a payment system
- CHIPS is a clearing system
- SWIFT is a messaging system

CHIPS and FedWire
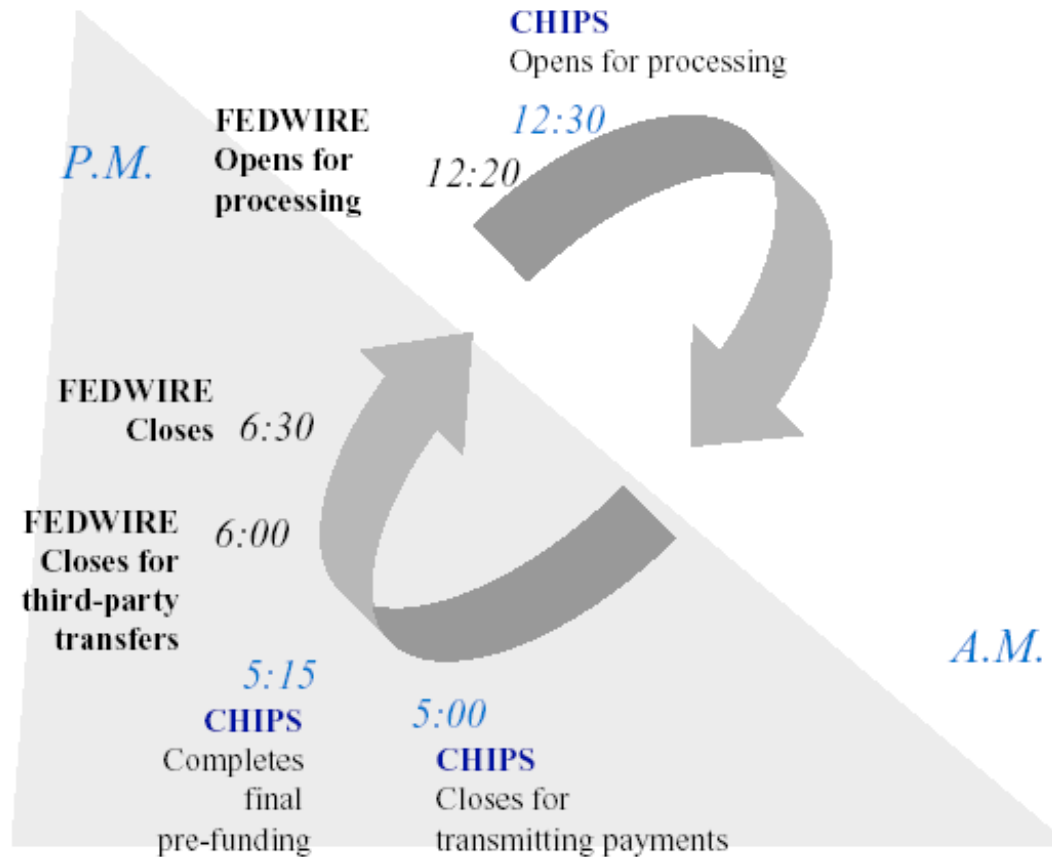
Another CHIPS Example

- A buyer in London needs to pay USD 1 million to a seller in Jacksonville, Florida
- The buyer only has GBP. He must buy USD in the UK and pay in USD in the US.
- Let's look at the USD leg of the CHIPS settlement
- Buyer's bank is L in London
- Bank L has a USD account in a correspondent bank A in NY that is a member of CHIPS
- Seller's bank J is in Jacksonville
- Bank J has a correspondent bank B in NY that is a member of CHIPS

CHIPS Operation

LONDON BANK L

JACKSONVILLE BANK J

1. BANK L TELLS BANK A TO PAY $1M TO J's ACCOUNT IN BANK B

SWIFT

2. BANK A VERIFIES FUNDS, ENTERS CHIPS TRANSACTION

9. CHIPS ADVISES B OF CREDIT AMT

10. B CREDITS J WITH $1M

SWIFT

NEW YORK BANK A (L'S CORRESPONDENT)

CHIPS

CHIPS

NEW YORK BANK B (J'S CORRESPONDENT)

FEDWIRE

CHIPS

CHIPS

A'S ACCOUNT

B'S ACCOUNT

3. CHIPS VERIFIES CREDIT LIMITS, ADJUSTS ACCTS INTERNALLY

4. AT 4:30, CHIPS TELLS BANK A HOW MUCH TO PAY VIA FEDWIRE

7. BY 5:45, CHIPS MAKES PAYMENT TO B

5. BANK A MUST PAY BY 5:30

FEDERAL RESERVE

A's ACCOUNT

B's ACCOUNT

CHIPS SETTLEMENT ACCOUNT

8. FED DEBITS CHIPS ACCOUNT; CREDITS B'S ACCOUNT

6. FED MOVES $$ INTO CHIPS ACCT

S.W.I.F.T.

- Society for Worldwide Interbank Financial Telecommunication
- Non-profit, headquarters in Brussels
- Financial messaging system, not a payment system
  - Settlement must occur separately
- >11,000 institutions, > 200 countries
- 8.5 billion messages per year: US$6 trillion per day
- Cost ~ $0.20 per message
- Private IP network
- swiftML
  - interoperable with ebXML

SWIFT Network (Dec 2019)

>11,000 financial institutions

>200 countries

~ 26 million messages/ day

8.5 billion messages in 2019

99.999 % availability

6 trillion USD/day

■ Connected

□ Not connected
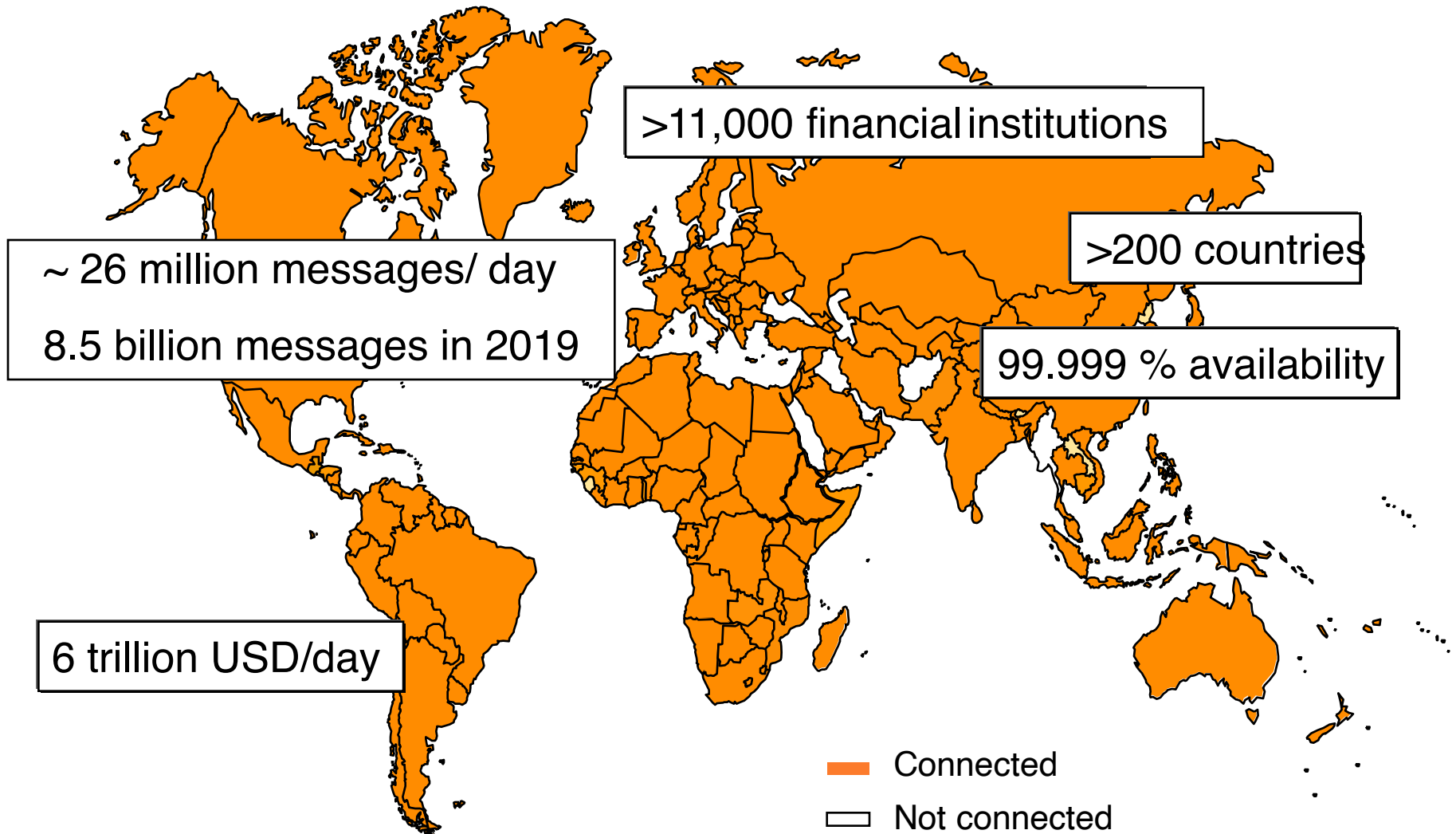
SWIFT Role in Payment
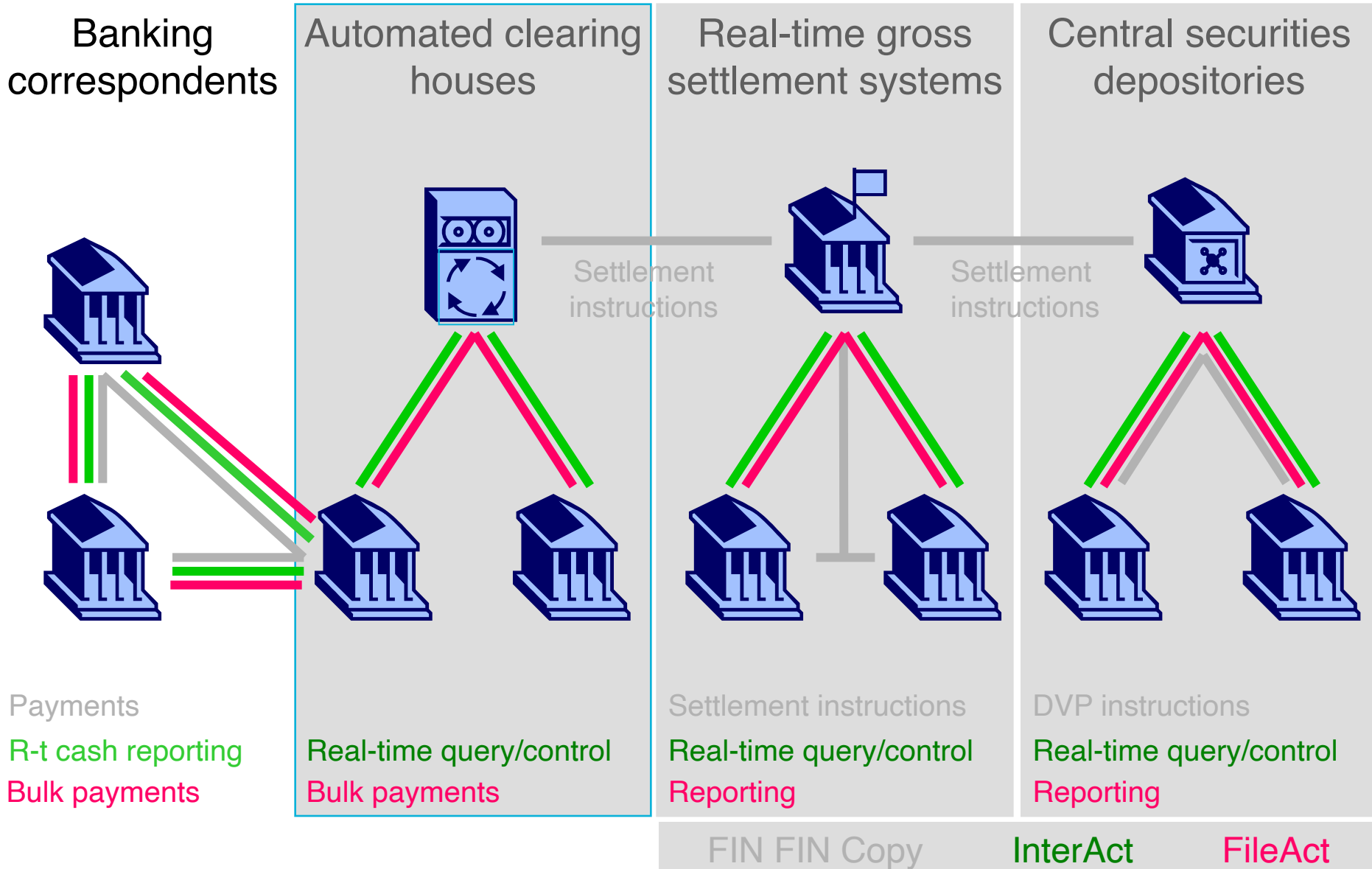
SWIFTNet Cash Reporting

US

GB

Provider USD

Provider GBP

Your balance is:
USD 2,000,000

Response

Response

SWIFTNet

Query

Query

What is the balance
of my USD account?

User US

User GB
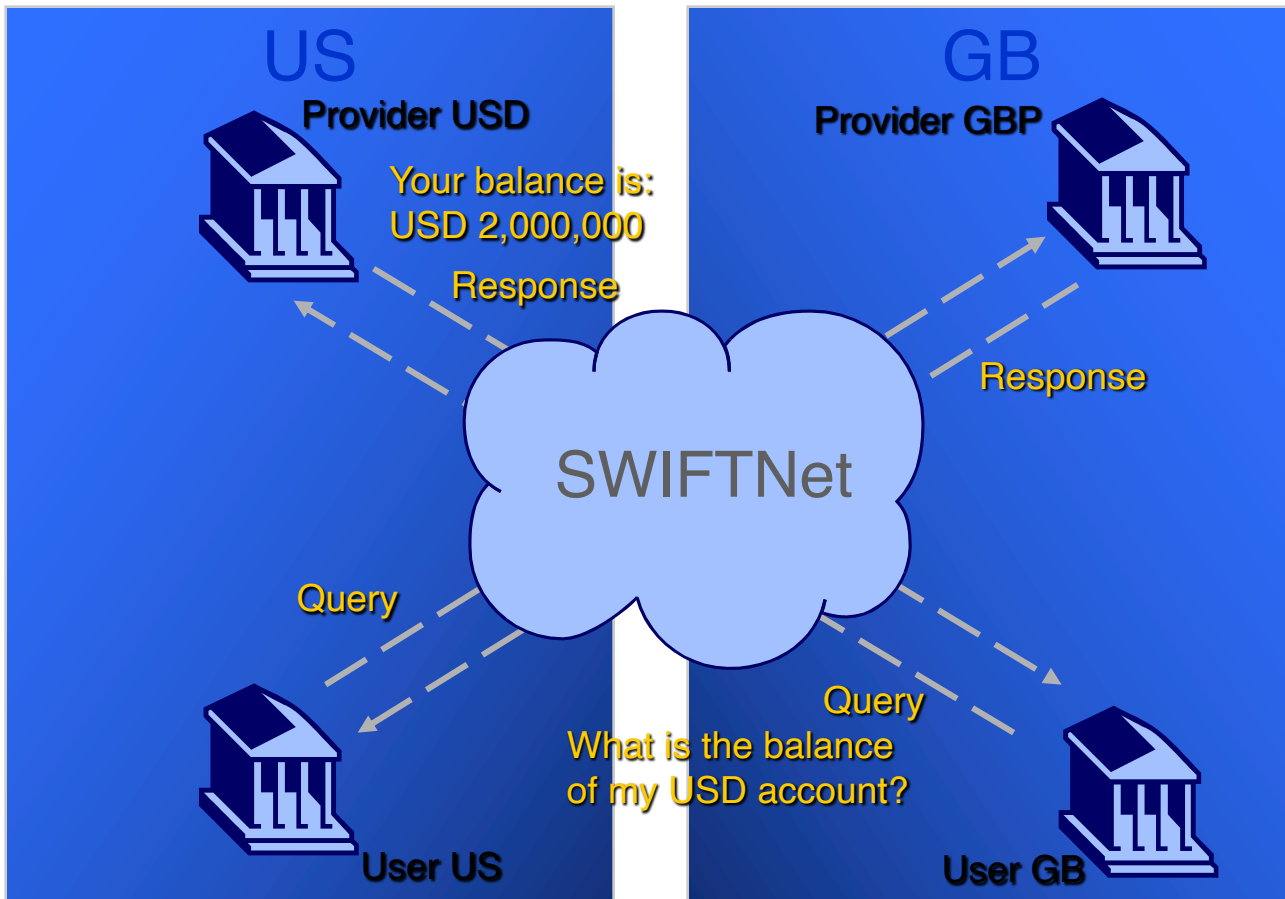
SWIFT E-payments Plus System

SOURCE: SWIFT
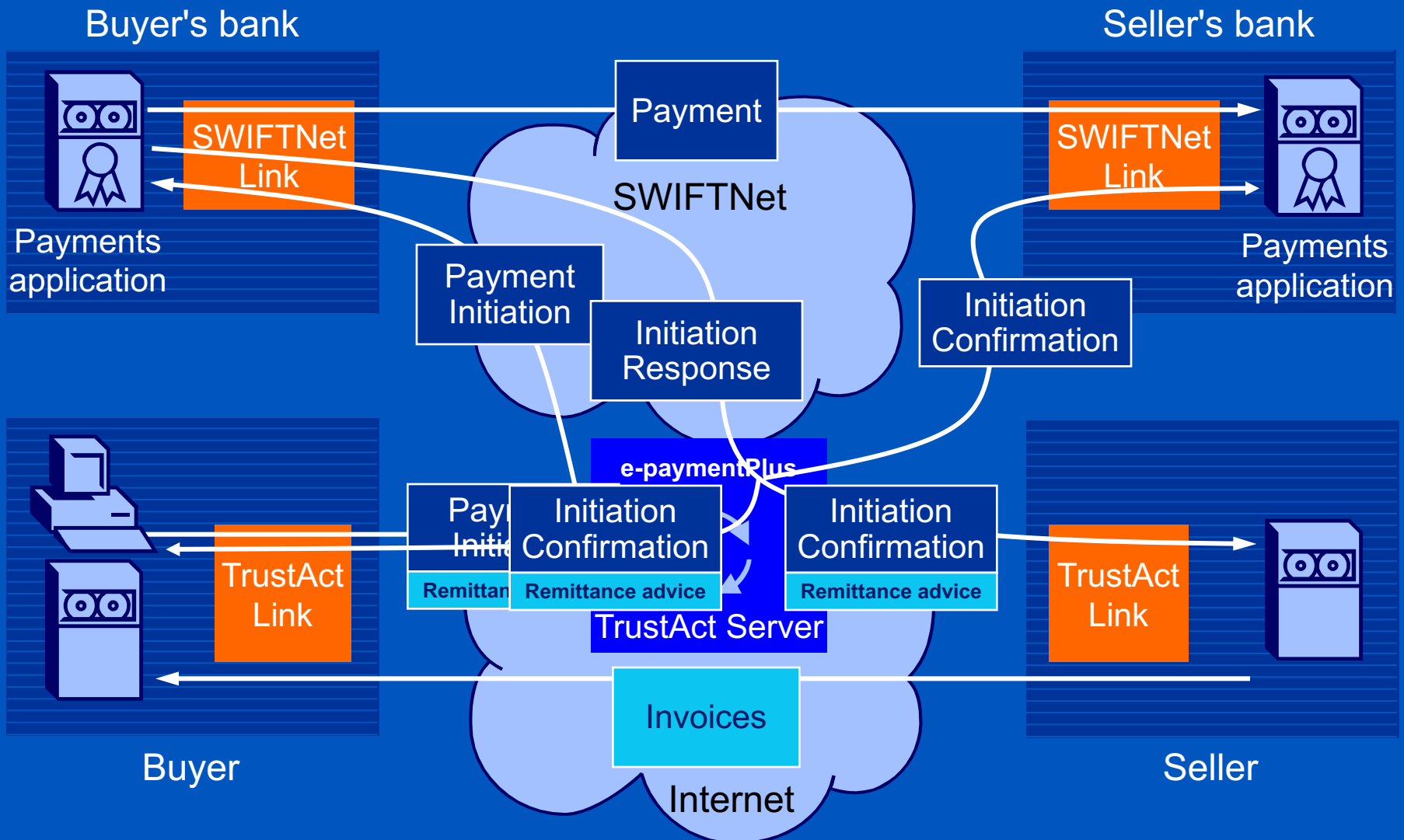
SWIFT Message Types

Category	Name
0xx	General Information
1xx	Customer Payments and checks
2xx	Financial Institutions Transfers
3xx	Financial Trading (FX, Loans, SWAPS, etc.)
4xx	Collections and Cash Letters
5xx	Financial Trading (Securities)
6xx	Precious Metals Trading and Syndications
7xx	Documentary Credits and Guarantees
8xx	Traveler's Checks
9xx	Cash Management and Customer Status

Message	Message Name
513	Client Advice of Execution
514	Trade Allocation Instruction
515	Client Confirmation of Purchase or Sale
517	Trade Confirmation Affirmation
528	ETC Client-Side Settlement Instruction
529	ETC Market-Side Settlement Instruction

SOURCE: SECURITIES OPERATIONS FORUM

More Clearing and Settlement Systems

Clearing and Settlement

Low value payments

Large value payments

Central Bank

National Clearing Centres

- Electronic
- Cards
- Securities

End of day

Net balances

Real Time Gross Settlement System RTGS

Net systems interfaces

Settlement accounts

Queuing mechanism

Exchange interface

CB Interfaces
Liquidity
G/L
Monitoring

Balances

Regional clearing

paper

Local clearing

paper

Electronic transactions

Real Time Commercial Bank Interface

HQ commercial banks

Regional offices

Local offices

Commercial banks

ATM, POS, PHONE, INTERNET, E-COMMERCE

Clients

Clients

Clients

History of Electronic vs. Traditional Payments (U.S., 2000)

	NUMBER (B)	VALUE (T)	AVG. VAL.
ELECTRONIC	49.5 (7.4%)	695 (88.9%)	$ 14,018
CHECK	69 (10.3%)	85 (10.9%)	$ 1,232
CASH	550 (82.3%)	2.2 (0.3%)	$ 4
TOTAL	669	782	$ 1,169

2400 TRANSACTIONS PER PERSON

USD 2.8M PER PERSON

6.6 PER PERSON PER DAY

USD 7700 PER PERSON PER DAY

SOURCE: NACHA

OLD History of U.S. Electronic Payment Volumes (circa: 2000)

	NUMBER	VALUE	AVG. VAL.
ACH	6,900 M	20,300 B	$ 2,942
ATM	13,200 M	800 B	$ 60
CREDIT CARD	20,000 M	1,400 B	$70
DEBIT CARD	9,300 M	400 B	$ 43
FEDWIRE	108 M	379,756 B	$ 3,516,000
CHIPS	58 M	292,147 B	$ 5,040,000
TOTAL	49,566 M	694,803 B	$ 14,018

SOURCE: NACHA

Payment Orders (Checks)

THIS CHECK IS AN <u>ORDER</u> TO MELLON BANK TO PAY $100 TO PAYEE OR HIS TRANSFEREE FROM THE CARNEGIE MELLON UNIVERSITY ACCOUNT

Check Processing

BANK A'S DEPOSITS
Check — Deposit Ticket

Encode

Sort/Balance

"On-Us"
Check — Deposit Ticket

Clearing House

Check — Cash Letter
"Clearing House"

Check — Cash Letter
"Direct Sends"

OTHER BANKS

BANK B

SOURCE: PNCBANK

U.S. Cheque Clearing

Point of Entry (1)
- Branch
- ATM
- Lockbox
- Accounts payable/remittance department
- POS

~40 billion checks transported

Daily+ courier check pick-up required

26 billion checks transported

Law requires physical presentment unless agreement exists

(2)

(3) Collecting Bank's Check Processing Center

(4)

(5*) Paying Bank A

Paying Bank B

Paying Bank C

Physical return of returned checks

2.1 billion checks returned

Clearing Payment Orders (Check)

CUSTOMER CMU OF MELLON BANK

1. CMU SENDS CHECK TO SHAMOS
"PAY SHAMOS $100"

CUSTOMER SHAMOS OF CITIBANK

9. MELLON SENDS CHECK BACK TO CMU

2. SHAMOS DEPOSITS CHECK AT CITI

MELLON BANK

CUSTOMER A	
CUSTOMER CMU	-100
. . .	
CUSTOMER Y	
CUSTOMER Z	

8. CLEARING HOUSE SENDS CHECK TO MELLON

4. CITI SENDS CHECK TO CLEARING HOUSE

CITIBANK

CUSTOMER A	
CUSTOMER B	
. . .	
SHAMOS	+100
CUSTOMER Z	

CLEARING HOUSE (FEDERAL RESERVE)

MELLON	-100
BANK A	
. . .	
BANK Z	
CITIBANK	+100

7. MELLON DEDUCTS $100 FROM CMU ACCOUNT

6. CLEARING HOUSE SENDS MELLON DEBIT INFO

3. CITIBANK CREDITS SHAMOS WITH $100

5. CLEARING HOUSE ADDS $100 TO CITI, SUBTRACTS $100 FROM MELLON

Settling Payment Orders (Checks)

1. AT END OF DAY, EACH BANK HAS A NET POSITIVE OR NEGATIVE CLEARING HOUSE BALANCE

2. BANKS WITH NEGATIVE BALANCES MUST PAY; THOSE WITH POSITIVE BALANCES RECEIVE MONEY

6. CLEARING HOUSE PAYS MELLON $34,299,321

4. CITI PAYS THE CLEARING HOUSE THROUGH RTGS

5. CLEARING HOUSE ADVISES MELLON IT WILL RECEIVE $34,299,321

3. CLEARING HOUSE INFORMS CITI IT MUST PAY $107,071,775

REAL-TIME GROSS SETTLEMENT SYSTEM (FEDWIRE)

MELLON	+34,299,321
BANK A	
. . .	
BANK Z	
CITIBANK	-107,071,775
CLEARING HOUSE	+107,071,775

MELLON BANK

CUSTOMER A	-15085
CUSTOMER CMU	+3167
. . .	
CUSTOMER Y	+728103
CUSTOMER Z	+35529

CLEARING HOUSE (FEDERAL RESERVE)

MELLON	+34,299,321
BANK A	
. . .	
BANK Z	
CITIBANK	-107,071,775

CITIBANK

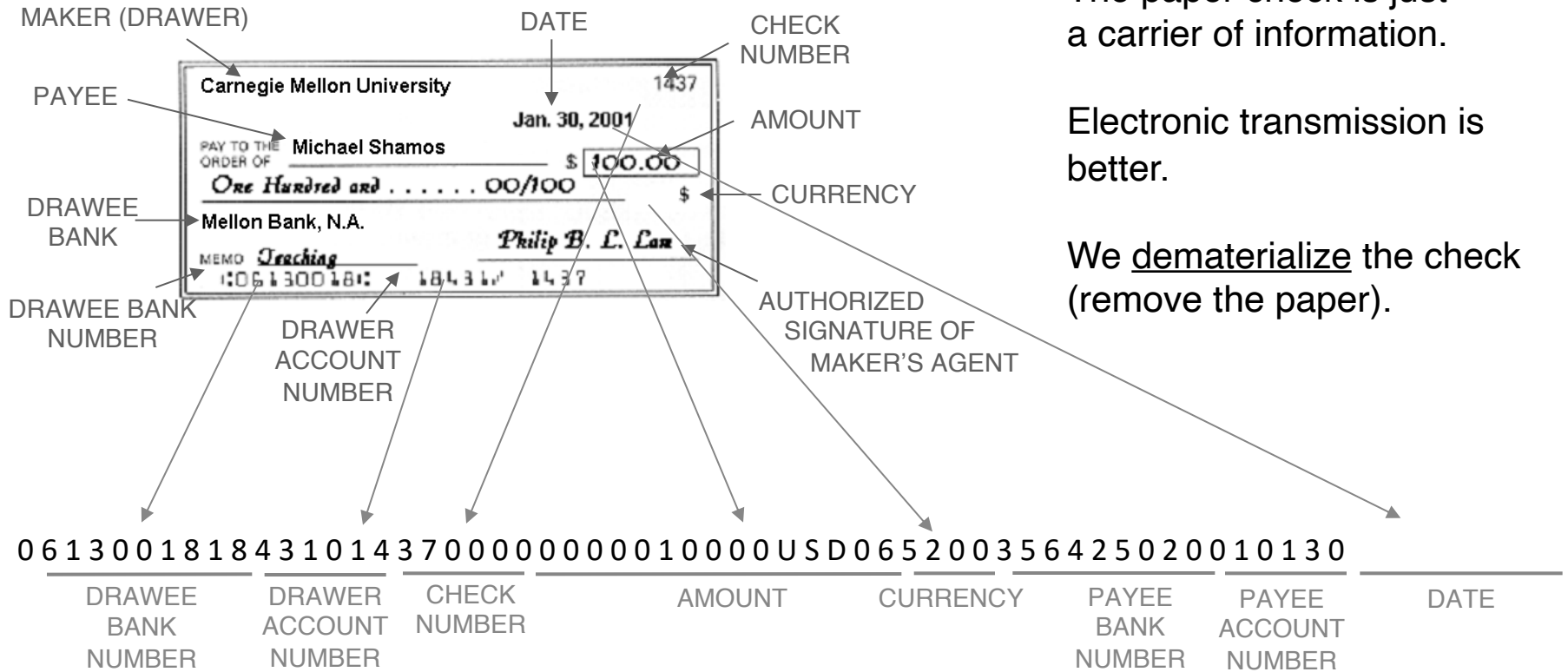|	
CUSTOMER A	+2786
CUSTOMER B	-988713
. . .	
SHAMOS	+100
CUSTOMER Z	-31872

Checks/ Cheques

- In 2012, U.S. had 18.3 billion checks per year, with total value of US$25.9 trillion => Ave. of US$1,415 per check
  - vs. 70 billions checks were written in 2001
- "On-Us" means "payer and payee in same bank"
- Interbank (payor and payee in different banks) -- requires <u>settlement</u>
  - Direct presentment ("direct sends")
  - Correspondent banks
  - Clearing house associations (150)
  - Federal Reserve system
- Complex laws re bank liability in check processing

Commercial Checks Collected through the Federal Reserve

The daily average volume and average daily value of items are based on the number of business days in each year.[1]

Year	Volume (millions of items)	Volume percent change	Value (billions of dollars)	Value percent change	Average daily volume (millions of items)	Average daily value (billions of dollars)	Average value per check (dollars)
2019	4,389	-7.4	8,318	-2.0	17.5	33.1	1,895
2018	4,740	-8.0	8,485	0.6	18.9	33.8	1,790
2017	5,153	-1.7	8,438	4.3	20.6	33.8	1,638
2016	5,241	-3.9	8,089	-0.3	20.9	32.2	1,543
2015	5,452	-5.0	8,109	0.0	21.7	32.3	1,487
2014	5,742	-4.1	8,109	1.9	22.9	32.3	1,412
2013	5,988	-6.5	7,960	-2.4	23.9	31.7	1,329
2012	6,402	-4.3	8,152	2.6	25.5	32.5	1,273
2011	6,691	-13.2	7,944	-10.0	26.7	31.6	1,187
2010	7,712	-10.2	8,825	-15.5	30.6	35.0	1,144
2009	8,585	-10.1	10,441	-24.1	34.1	41.4	1,216
2008	9,545	-4.6	13,760	-13.5	37.9	54.6	1,442
2007	10,001	-9.8	15,899	-3.3	39.8	63.3	1,590
2006	11,083	-9.4	16,443	4.8	44.2	65.5	1,484
2005	12,228	-12.1	15,685	9.8	48.7	62.5	1,283
2004	13,904	-12.0	14,286	-7.4	55.0	56.0	1,028
2003	15,806	-4.7	15,431	2.7	63.0	61.0	976
2002	16,587	-1.9	15,033	1.2	66.0	60.0	906
2001	16,905	-0.5	14,853	7.2	67.0	59.0	879
2000	16,994	-0.5	13,849	0.4	67.0	55.0	815

Electronic Check Clearing

The paper check is just a carrier of information.

Electronic transmission is better.

We dematerialize the check (remove the paper).

MAKER (DRAWER)

DATE

CHECK NUMBER

PAYEE

AMOUNT

DRAWEE BANK

CURRENCY

DRAWEE BANK NUMBER

AUTHORIZED SIGNATURE OF MAKER'S AGENT

DRAWER ACCOUNT NUMBER

Carnegie Mellon University   1437
PAY TO THE ORDER OF   Michael Shamos   Jan. 30, 2001 $ 100.00
One Hundred and . . . . . . 00/100 $
Mellon Bank, N.A.
MEMO Teaching   Philip B. L. Lam
⑆061300181⑆ 184311⑈ 1437

0 6 1 3 0 0 1 8 1 8 4 3 1 0 1 4 3 7 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 U S D 0 6 5 2 0 0 3 5 6 4 2 5 0 2 0 0 1 0 1 3 0

| DRAWEE BANK NUMBER | DRAWER ACCOUNT NUMBER | CHECK NUMBER | AMOUNT | CURRENCY | PAYEE BANK NUMBER | PAYEE ACCOUNT NUMBER | DATE |

Only the information is sent to the clearing house

Automated Clearing House (ACH) in U.S.

- Nationwide wholesale electronic payments system
- Transactions not processed individually
- Banks send transactions to ACH operators
- Batch processing store-and-forward
- Sorted and retransmitted within hours
- Banks
    - Originating Depository Financial Institutions (ODFIs)
    - Receiving Depository Financial Institutions (RDFIs)
- Daily settlement by RTGS
- Posted to receiver's account within 1-2 business days
- Typical cost: $0.02 per transaction; fee higher

Automated Clearing House (ACH)

- High-volume, small value payment orders between financial institutions
  - largely recurring payments: payroll, mortgage, car loan, Social Security
  - U.S. Treasury Financial Management Service: cost to send gov't check: $0.42. Cost of epayment: $0.02.
- Automated Teller Machines (ATM)
- Debit-card point-of-sale payments
- Telephones or PC bill payments.
- Direct deposit (e.g. Payroll)
- Electronic benefits transfer

Automated Clearing House

- Processes dematerialized checks (digital data only)
- Both debits and credits allowed
- ACH processors:
  - American Clearing House Association (American)
  - Federal Reserve System
  - New York Automated Clearing House (NYACH)
  - VISANet ACH
- 1998: 5.3B transactions, $16.4T
- ACH cost: less than 1 cent per transaction

ACH Debit Transaction

1. BUYER AUTHORIZES SELLER TO DRAW $X FROM BUYER'S ACCOUNT IN BUYER'S BANK

2. SELLER ASKS HIS BANK TO SEND TRANSACTION TO AUTOMATED CLEARINGHOUSE

BUYER → **SELLER**

7. SELLER'S BANK CREDITS SELLER'S ACCOUNT WITH $X

8. BUYER'S BANK ADVISES BUYER OF PAYMENT

BUYER'S BANK

SELLER'S BANK
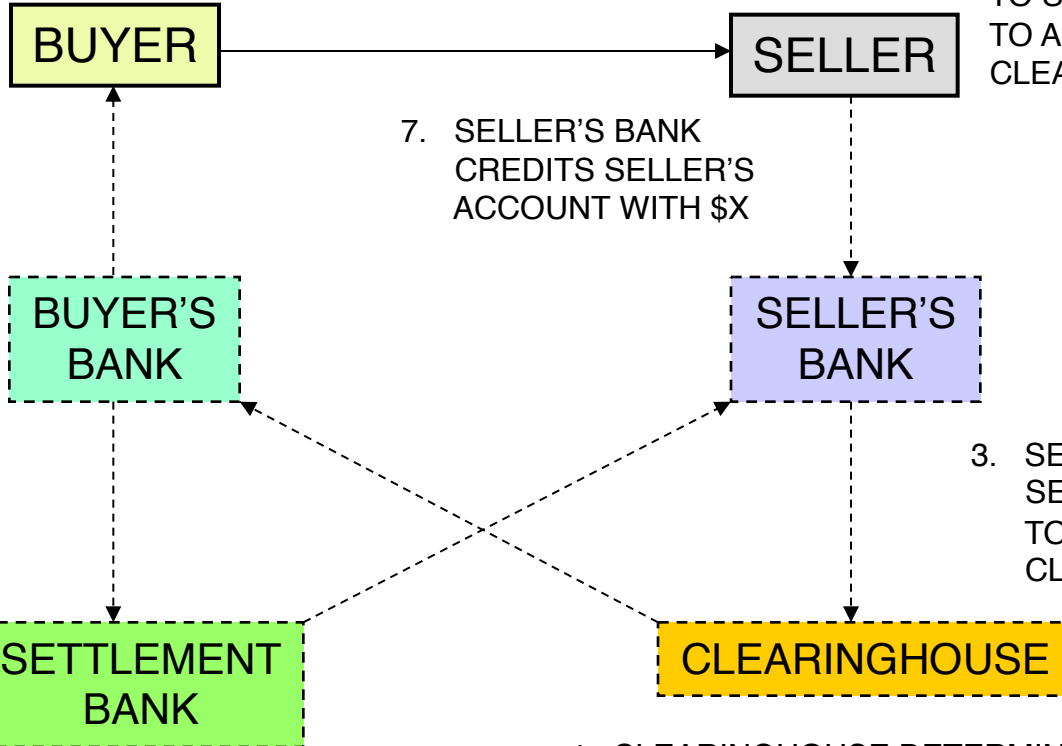
5. BUYER'S BANK PAYS $X TO SETTLEMENT BANK

3. SELLER'S BANK SENDS TRANSACTION TO AUTOMATED CLEARINGHOUSE

SETTLEMENT BANK

CLEARINGHOUSE

6. SETTLEMENT BANK PAYS $X TO SELLER'S BANK

4. CLEARINGHOUSE DETERMINES THAT BUYER'S BANK OWES SELLER'S BANK $X (ALL TRANSACTIONS ARE NETTED)

ACH Credit Transaction

1. BUYER SENDS AN ORDER TO BUYER'S BANK TO CREDIT $X TO SELLER'S ACCOUNT IN SELLER'S BANK

BUYER

SELLER

2. BUYER'S BANK SENDS TRANSACTION TO AUTOMATED CLEARINGHOUSE

6. SELLER'S BANK CREDITS SELLER'S ACCOUNT WITH $X

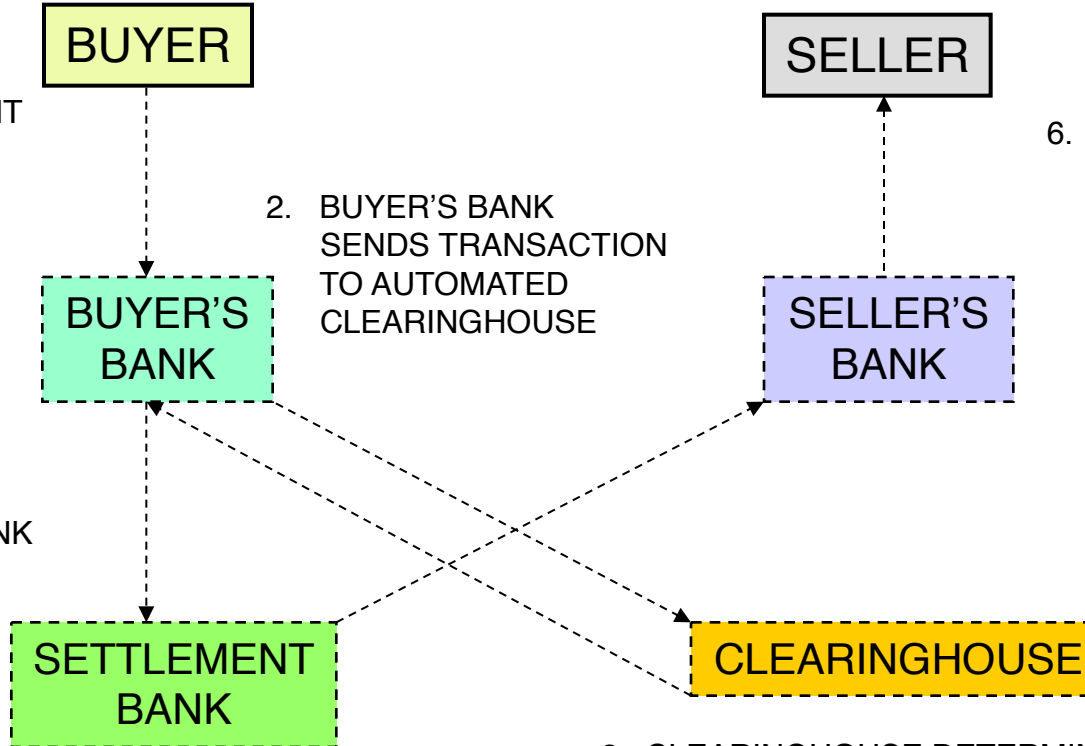**BUYER'S BANK**

SELLER'S BANK

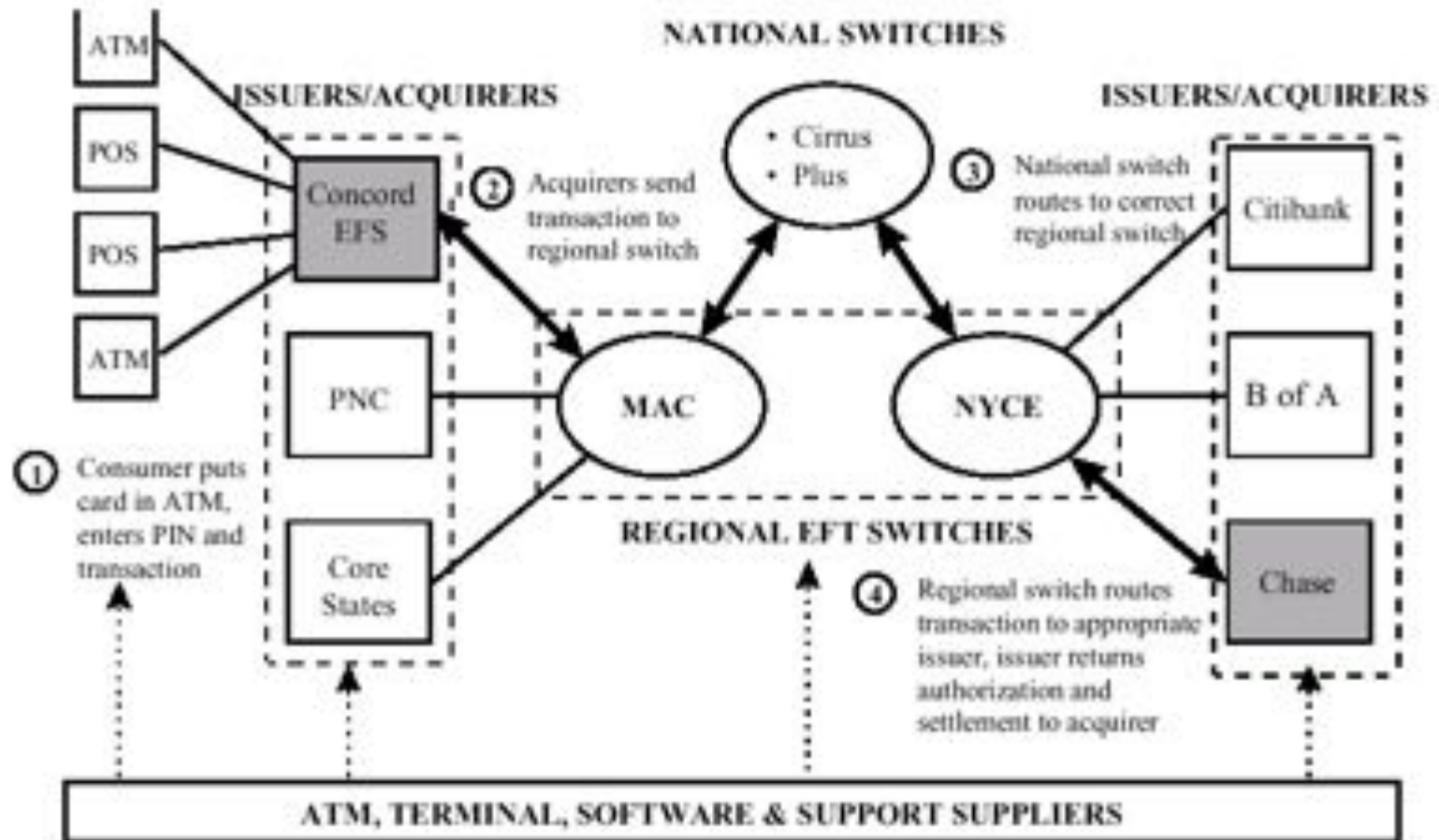4. BUYER'S BANK PAYS $Y TO SETTLEMENT BANK

SETTLEMENT BANK

CLEARINGHOUSE

5. SETTLEMENT BANK PAYS $YTO SELLER'S BANK

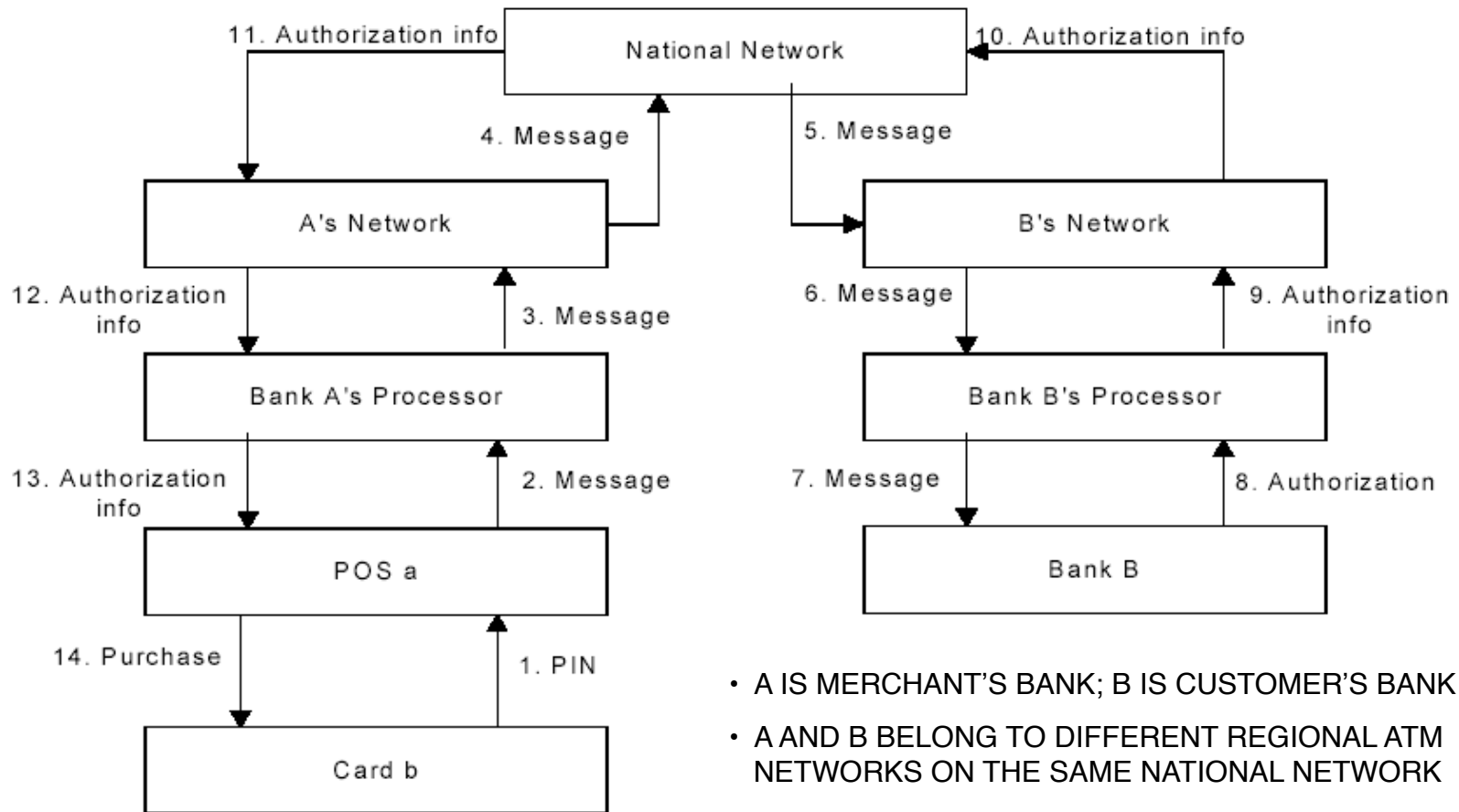3. CLEARINGHOUSE DETERMINES THAT BUYER'S BANK OWES SELLER'S BANK $Y (ALL TRANSACTIONS ARE NETTED)

ATM and Debit Networks

SOURCE: U.S. BANCORP

Debit Card Authorization

- A IS MERCHANT'S BANK; B IS CUSTOMER'S BANK
- A AND B BELONG TO DIFFERENT REGIONAL ATM NETWORKS ON THE SAME NATIONAL NETWORK
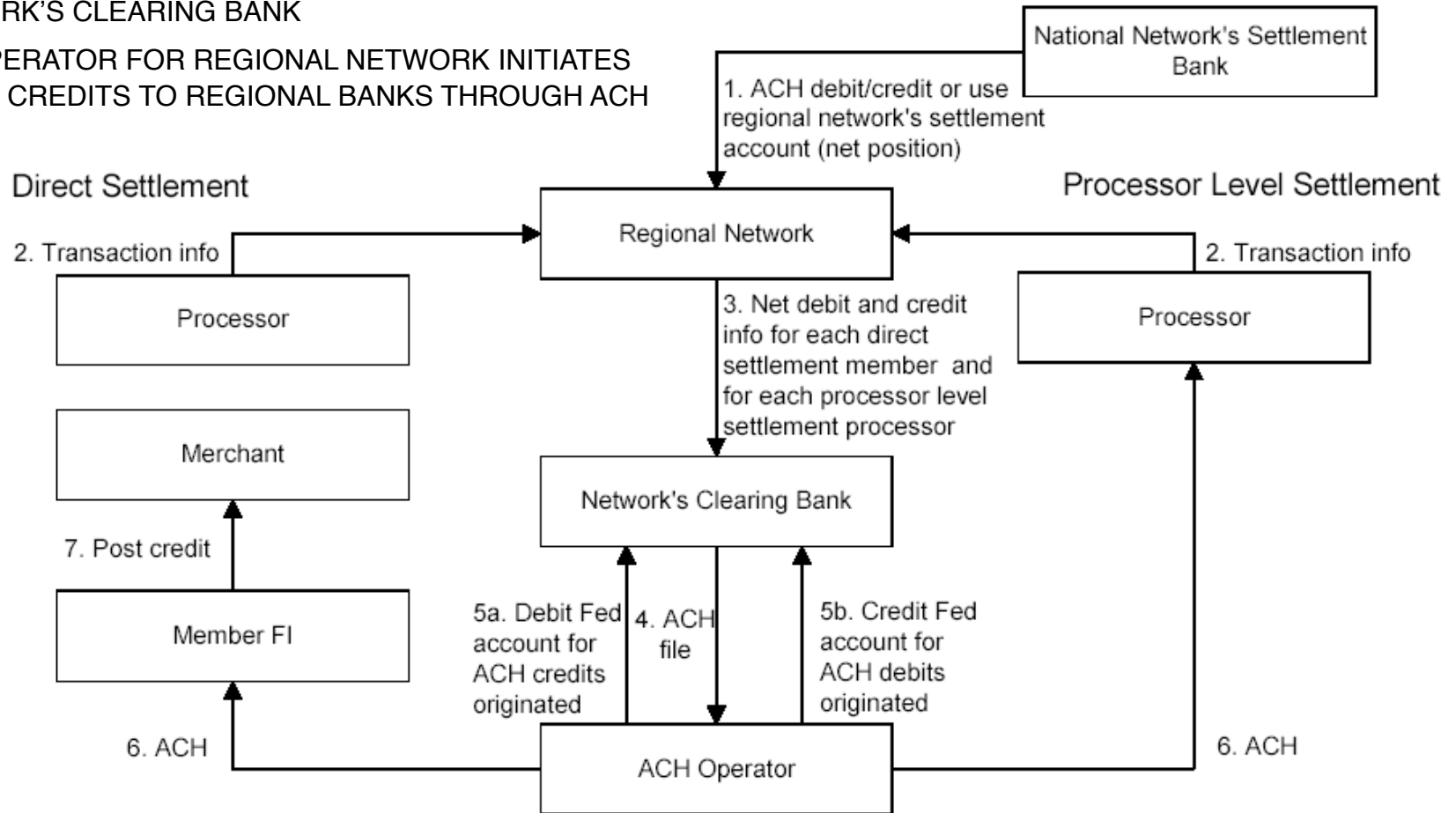- DEBIT IS IMMEDIATE WHEN BANK B AUTHORIZES

SOURCE: HAYASHI, WORLD BANK

Debit Card Settlement

1. NATIONAL NETWORK CLEARS FOR ITS REGIONAL NETWORKS,
     SETTLES REGIONAL NETWORK'S ACCOUNTS IN CENTRAL BANK

2-3. REGIONAL NETWORK CLEARS FOR ITS MEMBERS THROUGH
     NETWORK'S CLEARING BANK

4-5. ACH OPERATOR FOR REGIONAL NETWORK INITIATES DEBITS AND CREDITS TO REGIONAL BANKS THROUGH ACH

National Network's Settlement Bank

1. ACH debit/credit or use regional network's settlement account (net position)

Direct Settlement

Processor Level Settlement

Regional Network

2. Transaction info

Processor

2. Transaction info

Processor

3. Net debit and credit info for each direct settlement member and for each processor level settlement processor

Merchant

Network's Clearing Bank

7. Post credit

Member FI

5a. Debit Fed account for ACH credits originated

4. ACH file

5b. Credit Fed account for ACH debits originated

6. ACH

ACH Operator

6. ACH

SOURCE: HAYASHI, WORLD BANK

Summary of Major Ideas

- Central banks play a central role in money movement
- Payment requires M1
- Foreign Exchange (FOREX)
- Gross v. Net settlement
- Foreign exchange requires two settlements
  - Timing of two settlements
  - Herstatt risk
  - PvP solution
- US Banking and Payment Systems
- International Payments Systems:
  - CHIPS (the actual payment systems) and
  - SWIFT (the messaging system used by CHIPS)
- Check processing is cumbersome: requires clearing and settlement.
- Automated Clearing House a US nation-wide wholesale clearing system for high-volume small-value payments among major institutions to support:
  - ATM processing, Debit card processing at Point-of-Sale, Payroll transfer, Inter-bank payments