Blockchain Technology And Applications

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What is Blockchain?

- A Linked List
  - Replicated
  - Distributed
  - Consistency maintained by Consensus
  - Cryptographically linked
  - Cryptographically assured integrity of data
- Used as
  - Immutable Ledger of events, transactions or time stamped data
  - Tamper resistant log
  - Platform to Create and Transact in Cryptocurrency
  - log of events/transactions unrelated to currency

Why Should we Learn about Blockchain?

Have you seen the news lately?

- Bitcoin
- Ethereum
- Blockchain for E-governance
- Blockchain for supply chain management
- Blockchain for energy management ……
- Soon: Block chain for Nirvana

Is it just a hype and hyperbole?

- Even if you do not care about cryptocurrency and its market volatility it is a technology of potential

Let’s First talk about Banking (a la Arvind Narayanan)

Regulatory Agency (RBI)

Customers

Bank

Bank Employee

How do you transact?

Your write a check or do internet transaction to pay a payee

Bank checks if you have balance > transaction amount

- If yes, it debits your account by balance = balance - transaction_amount
  - credit's payee's account by payee.balance = payee.balance + transaction_amount
- If no, the transaction is invalid and rejected.

You can check your transaction list online, or check the monthly statement

Who maintains the ledger?

- Bank Does
- What if Bank allows an invalid transaction go through
  - Invalid = you did not authenticate the transaction
  - Invalid = your balance was not sufficient but transaction was made

Bank Frauds

You find a check was used to pay someone but you never wrote the check

- Someone forged your check and/or signature

You did sign a check for x amount, but the amount field was modified

- How do you prove to the bank that an extra 0 was not there in your signing time?

The monthly statement says that you did a transaction but you did not recall or the amount of a transaction is different from what you had done

- Someone got your password, and possibly redirected OTP to another SIM (SIM Fraud)
- Bank employees themselves might have done something

How do you argue to the bank? (Non-repudiation)

How do you argue that the amount was modified? (Integrity)

Finally, do you tally your transactions when you receive your monthly statement?

- Most people do not

Supply chain and provenance

Your buy ice cream for your restaurant from supplier B

Supplier B actually transports ice cream made in Company C's factory

Upon delivery, you have been finding that your ice cream is already melted

Who is responsible?

- Supplier B is keeping it too long on the delivery truck?
- Supplier B's storage facility has a temperature problem?
- Supplier C says it's supplier B's fault as when picked up – ice cream was frozen
- Supplier B says that when received, the temperature was too high, so C must have stored it or made it wrong
- How do you find the truth?
  - Put temperature sensors in B's truck and storage, C's factory and storage, and sensor data is digitally signed by the entity where the sensor is placed and put in a log
  - You check the log – but B and C both have hacked the log and deleted some entries?
- What to do?

Land Record

Have you watched “Khosla ka Ghosla”?

You buy a piece of land

Someone else claims to own the land

But the one who sold you the land showed you paper work

Land registry office earlier said that the owner was rightful

Now they say that they made a mistake – it was owned by the other person

You already paid for the land – to the first person

First person goes missing

How does any one prove who changed the land record?

- The government employees?

Bitcoins and other cryptocurrencies

Too much interest by investors to park their assets

Less use as a medium of value exchange

Private Key stealing or private keys at exchanges — risk

Coding vulnerabilities — risk

Volatility

Energy Waste — climate impact

Too much concentration in one country — risk

Regulatory risk

Usage for criminal activities — Silk Road

Again, What is a blockchain?

Blockchain technology is a digital innovation that has the potential to significantly impact trusted computing activities and therefore cybersecurity concerns as a whole.

Attractive properties of Blockchain

- Log of data with digital signature
- Immutable (once written – cryptographically hard to remove from the log)
- Cryptographically secure – privacy preserving
- Provides a basis for trusted computing on top of which applications can be built

Trust Model

Cyber Security is all about who you trust?

- Trust your hardware to not leak your cryptographic keys?
- Trust your O/S to not peek into your computation memory?
- Trust your hypervisor to not mess up your process memory?
- Trust your application to not be control hijacked or attack other applications?

Where is your trust anchor?

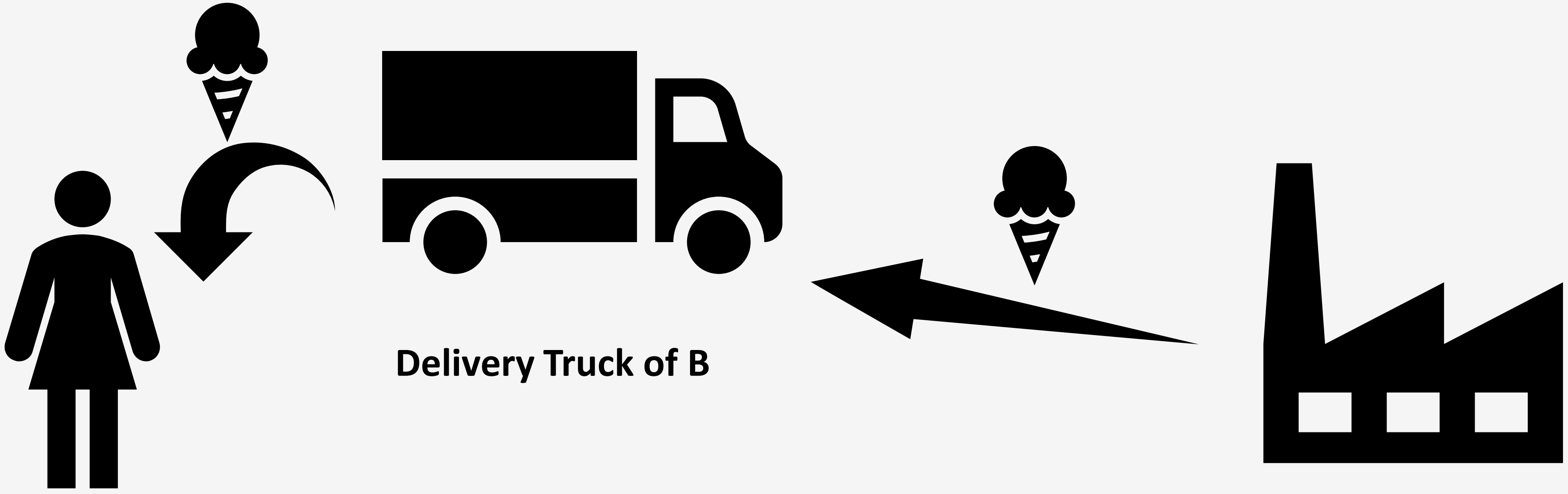
- Hardware?
- Operating system?
- Application?
- Manufacturer?

Trust Model (2)

In many real life transactional activities – trust model is the inverse of the threat model

- Do you trust your bank to not take out small amounts from your balance all the time? (Watch – “Office Space”)
- Do you trust the department of land records to keep your record’s integrity?
- Do you trust UIDAI officials to keep your aadhaar data from unauthorized access?
- Do you trust your local system admins to not go around your back and change settings, leak passwords, change database entries, and remove their action from system logs?
- In the patch management system of your enterprise, are the patches being put -- all have digital certificates? Who put them? Do you trust your employees to do the correct thing and not put a malware as patch?

Back to the supply Chain Story (Herlihy)



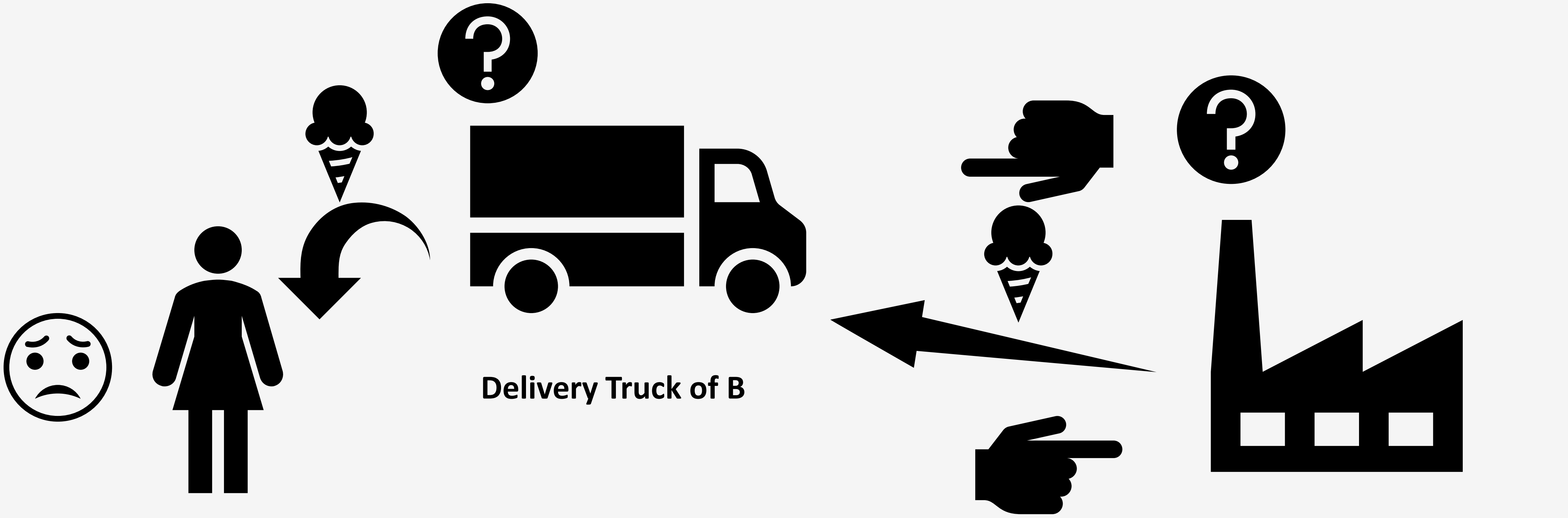
Delivery Truck of B

Restaurant A

Ice cream Factory and Storage C

Ice Cream Supply Chain to Restaurant A from Factory C via Supplier B

Ice cream is melted



Delivery Truck of B

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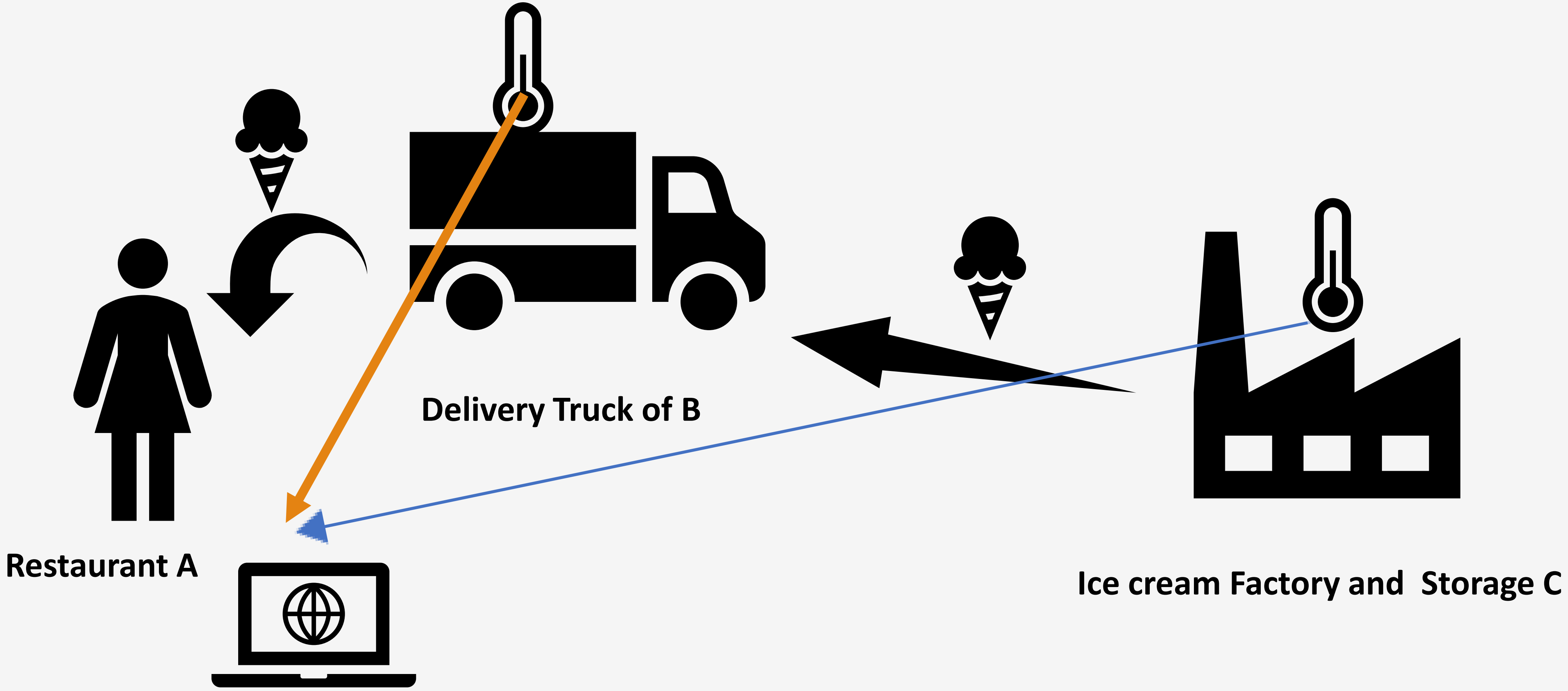
Ice Cream Supply Chain to Restaurant A from Factory C via Supplier B

Use IoT to create non-repudiation



IoT sensors sends real-time data to the server at Restaurant A to periodically show the factory and the truck temperatures to Restaurant A

What can go wrong?

- IoT sensor data may be intercepted by a middle man and changed before it reaches the server (**data integrity**)
- IoT sensors may be stopped and old readings may be replayed (**replay attack**)
- What the server gets purportedly from factory C, may be manufactured by supplier B (**Authenticity**)
- If restaurant A claims that C's temperature reading shows that ice cream was melting in the storage, C can say that message you received is not from me – there was an MITM attack (**repudiation**)

- So restaurant A will not be able to pinpoint any one in the supply chain with full confidence!!

What can be done?

- Use a message integrity proof (Hashing)
- Use digital signature of the individual IoT devices (Authenticity and non-repudiation)
  - assuming the digital signatures cannot be forged
  - private keys are kept safe
- Use authentic time stamping with the IoT data before hashing for integrity (avoid replay attacks)
- So now factory A can pinpoint with some basic security assumptions about this infrastructure

Concurrency Issue

- A has other suppliers for other goods required for its business (multiple concurrent supply chains)
- B and C has multiple other consumers of their services
- So if there are N suppliers who are also consumers of some of these entities, we have an N^2 messaging problem

A offers that every one can look up their data from my server, so you can get linear number of messaging

But do you trust A as purveyors of your data?

Solutions?

- Have a trusted authority or a cloud provider to become a publish-subscribe service provider
- Every supplier sends their IoT data with message integrity, authentication code etc to the cloud server
  - Every consumer subscribes to the events they are interested in on the cloud
  - Every supplier becomes authenticated data generator on the cloud

What if the cloud provider cannot be trusted?

Create a framework on which data is crowd sourced, validated by the crowd for the crowd?

- You get a block chain
- But now the question is as concurrent messages come in to this framework, how do you order them?

DISTRIBUTED CONCENSUS IS REQUIRED TO DECIDE

1. of all messages coming in concurrently how are they ordered

2. But if some of the crowd are malicious, and tries to allow data that are wrong, or ordered wrong?

3. You need Byzantine fault-tolerant consensus

Conclusion

- Blockchain is about
  - Distributed Record Keeping
  - Trust Model varies – but usually single point of trust is not good
  - Based on Trust Model –
    - Permissioned Blockchain
    - Non-permissioned or public block chain
    - Also, private blockchain
  - Data integrity (No one has tampered with the data after its creation)
  - Authenticated Transactions or event logging
  - Strong Cryptographic Application
- Blockchain is certainly not ONLY
  - Cryptocurrency