Theory And Applications of Blockchain

Course Introduction

Department of Computer Science and Engineering

INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

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The Myth Busters

- Blockchain ≠ Bitcoin (or any other cryptocurrencies)
  - If you want to take this course to trade cryptocurrencies, this course is not for you !!
  - We do not want to make any comment on whether Bitcoin is good or whether Bitcoin should be blocked

Prerequisite for this Course

- Good programming skills
- Good grasp in Data Structures and Algorithms
- Concepts from operating systems
  - Process management
  - Inter-process communication
  - Memory management
  - Resource virtualization
- Concepts from computer networks
  - Network protocol stack
  - Peer to Peer networks
  - Network performance metrics

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- Anything and everything in the world cannot be solved using a blockchain
  - Blockchain is good but may not be so "stellar" the way it is projected

Then why should you take this course

- To avoid all the hypes and apply Blockchain as a solution at the right place …

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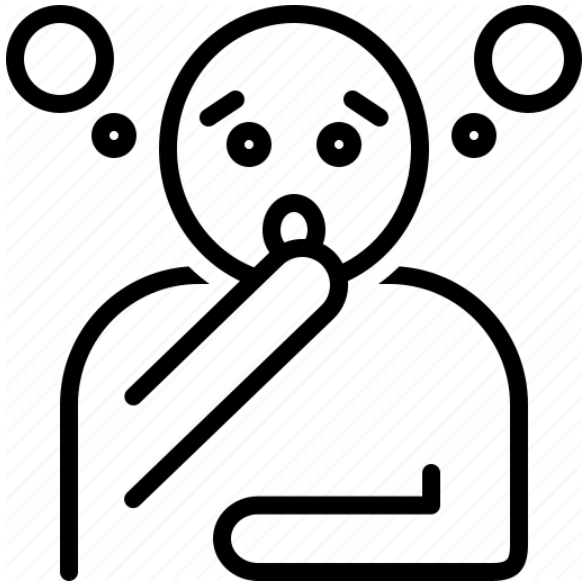
- Anything and everything in the world cannot be solved using a blockchain
  - Blockchain is good but may not be so "stellar" the way it is projected
- You cannot replace a database with a blockchain
  - Blockchain is not a distributed database
  - Blockchain is not designed to securely store ANY data

Then why should you take this course

- To avoid all the hypes and apply Blockchain as a solution at the right place …

So, what is the right place?



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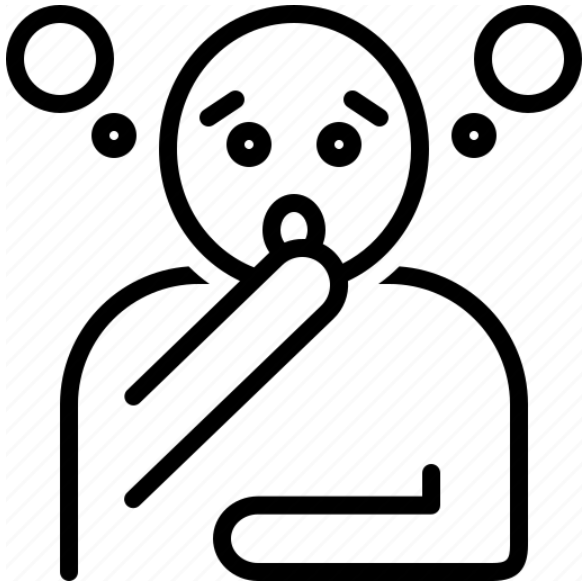

Let's explore the course !!

What We'll Cover in This Course?

- Blockchain as a Data Structure
  - How does a blockchain look like?
  - How do we efficiently store data in a blockchain?
  - How can we efficiently manage data insertion in a blockchain? What is the complexity of data insertion and searching a data item within a blockchain?

What We'll Cover in This Course?

- Blockchain as a Networking Protocol
  - For what types of network architectures, can we design a blockchain-based solution?
  - What different networking protocols are used in blockchain?
  - How does the design of various network protocols impact blockchain performance?
  - How can we optimize the networking architecture to make a blockchain performant?

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- Blockchain as a Security Blackbox
  - How do we ensure the security of the data stored in a blockchain?
  - What are the attack models that can be applied on a Blockchain architecture?
  - What level of data security can be ensured with the help of a blockchain?
  - How can we optimize various cryptographic operations to make a Blockchain implementation performant?

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  - How does the design of various network protocols impact blockchain performance?
  - How can we optimize the networking architecture to make a blockchain performant?

- Blockchain as a Distributed System
  - What happens when some participants in a blockchain-based system starts behaving maliciously?
  - How do we ensure the correctness of blockchain protocols?
  - How do we ensure "safety" and "liveness" of blockchain operations?

What We'll Cover in This Course?

- Blockchain as a Programming Framework
  - How can you write a "smart" distributed application on top of blockchain?
  - What are the supported features for such a programming framework?
  - What can and cannot be done with such a programming framework?

What We'll Cover in This Course?

- Blockchain as a Programming Framework
  - How can you write a "smart" distributed application on top of blockchain?
  - What are the supported features for such a programming framework?
  - What can and cannot be done with such a programming framework?

- Finally, the Blockchain Applications
  - What are the different types of applications that can be realized with blockchain?
  - What are the different types of applications that cannot be realized with blockchain?

The Different Blockchain Frameworks That We'll Explore

Ethereum

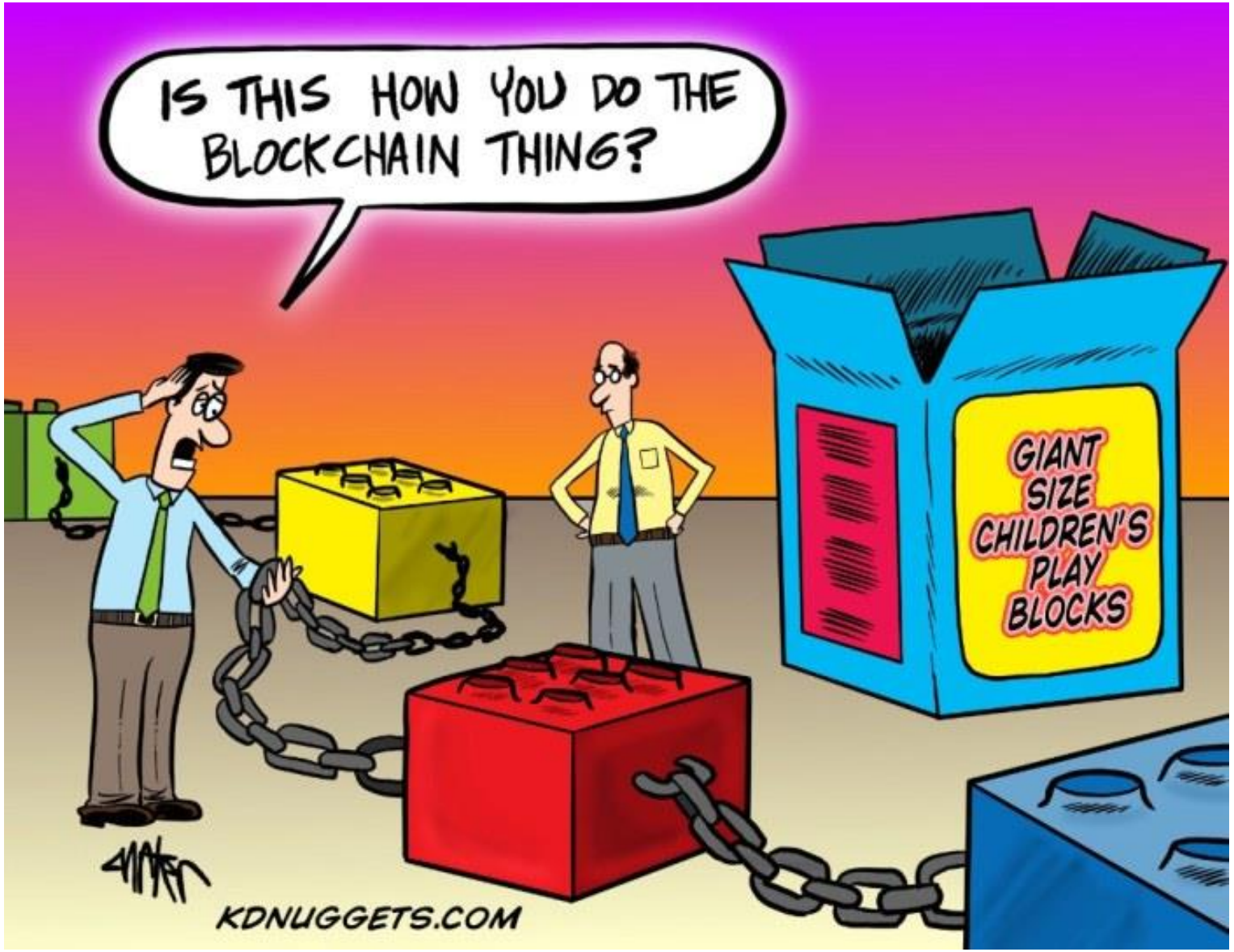
Hyperledger
FABRIC

Hyperledger
INDY

Grading

- 4-5 Programming Assignments (Covers Tutorials): 40 Marks
  - All the assignments may not have equal weights – will be discussed during the tutorials
  - Tutorials will be on Fridays (But not on all Fridays!!)
- Mid-Sem: 25
- End-Sem: 35

So, What is a Blockchain?



Supply Chain Management: The Players and the Game

Supply Chain in Petroleum Industry

Crude Purchase

Supply Chain in Petroleum Industry

Crude Purchase

Crude Transportation

Supply Chain in Petroleum Industry

Crude Purchase

Crude Transportation

Crude Storage

Supply Chain in Petroleum Industry

Crude Purchase

Crude Transportation

Crude Storage

Refining

Supply Chain in Petroleum Industry

Crude Purchase

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Distribution

Supply Chain in Petroleum Industry

Crude Purchase

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Retail

Petroleum Supply Chain in India

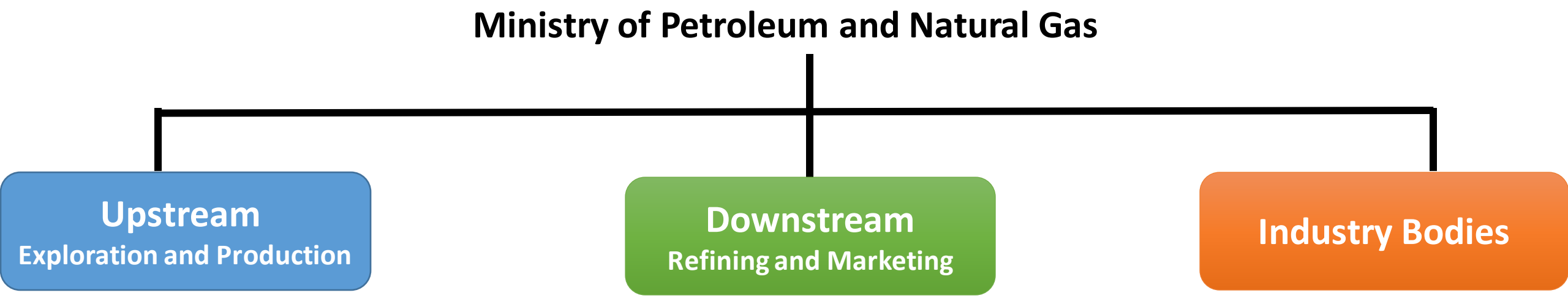
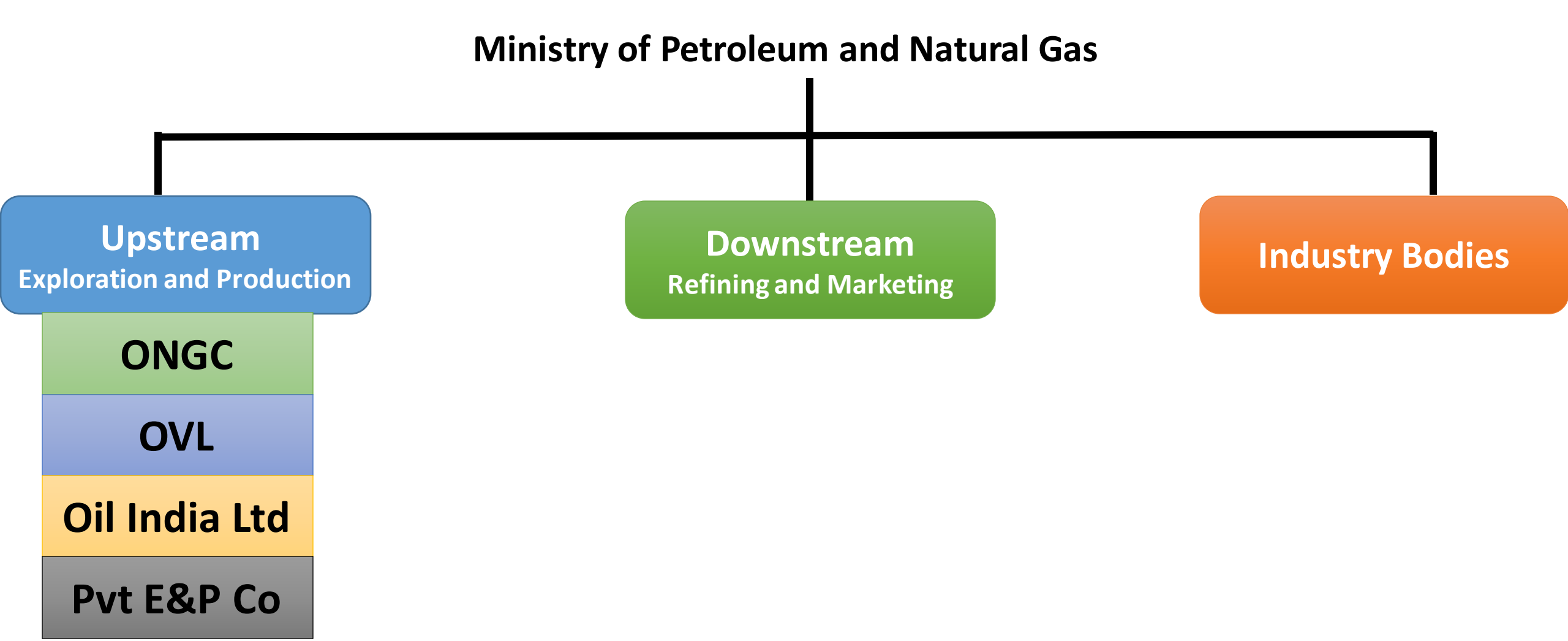
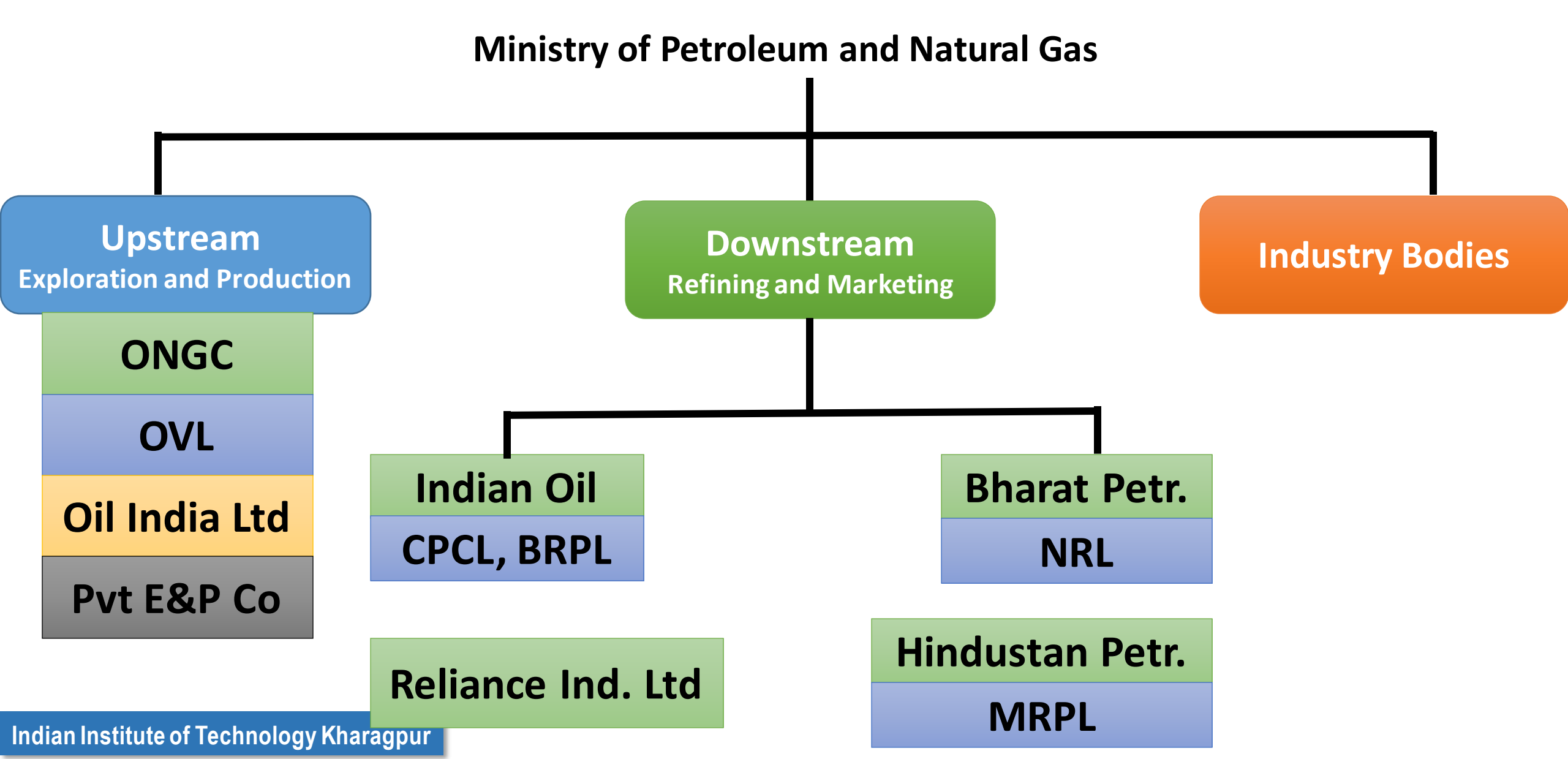


Diagram Source: https://www.slideshare.net/naseer9848/supply-chain-and-logistics-issues-of-crude-oil-in-india

Petroleum Supply Chain in India



Petroleum Supply Chain in India



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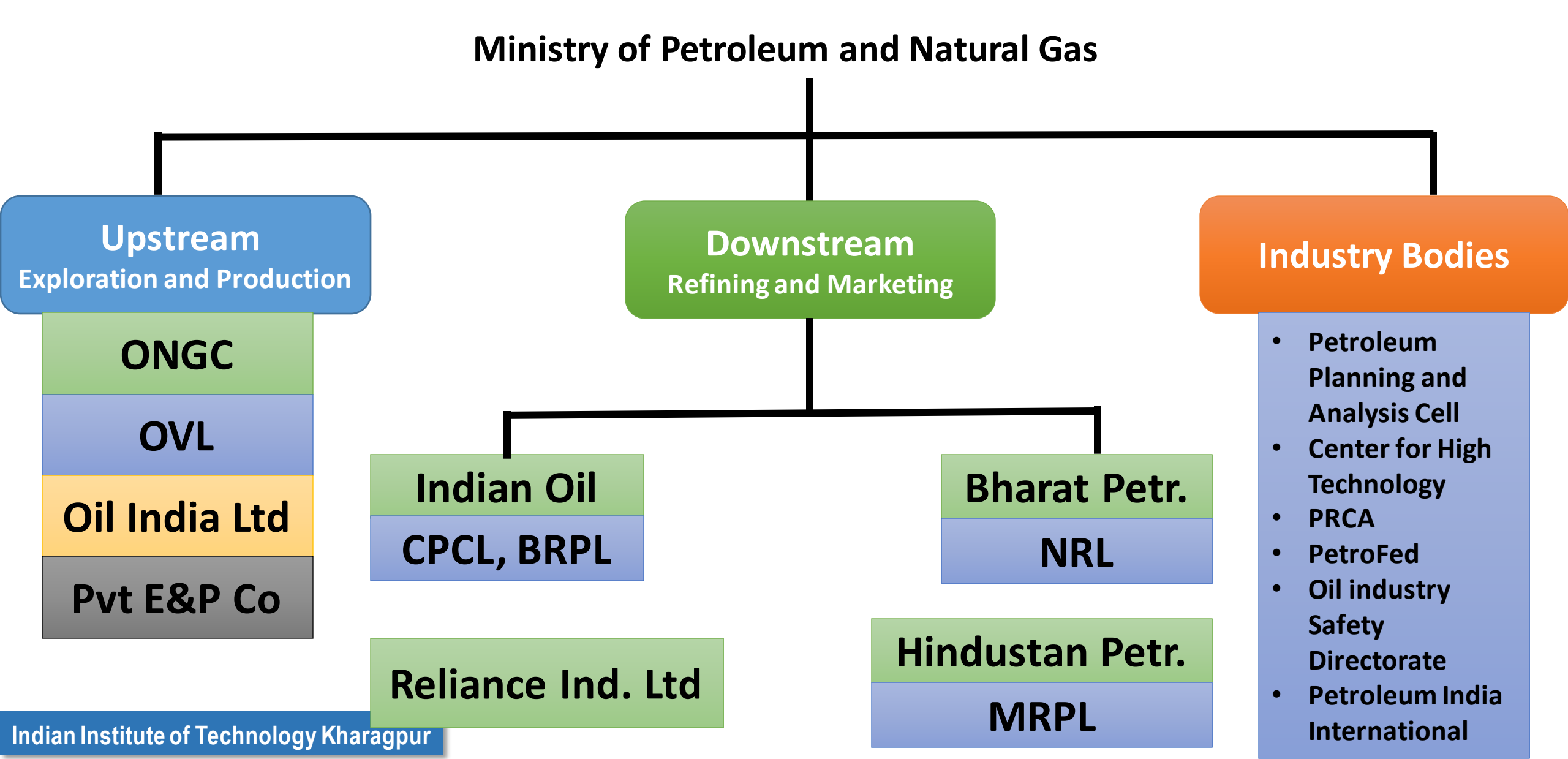

Requirements of a Successful Supply Chain

- Minimization of material procurement
- Maximization of manufacturing capacity and sales
- Meet demand numbers
- Respond quickly to market opportunity by purchasing the production shortfall from other players
- Objective of each production unit would be to maximize the throughput and its margin
- Procurement would purchase the feedstock with not the best yields at lowest cost

Information Source: https://www.slideshare.net/naseer9848/supply-chain-and-logistics-issues-of-crude-oil-in-india

Requirements of a Successful Supply Chain

- Minimization of material procurement

Needs Strong Coordination among the Players

its margin

- Procurement would purchase the feedstock with not the best yields at lowest cost

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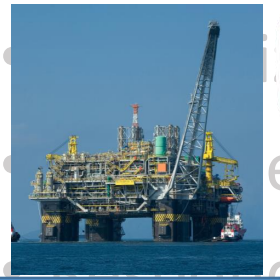



How do we obtain Real-time Information from the Stakeholders?

its margin

- Procurement would purchase the feedstock with not the best yields at lowest cost

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Requirements of a Successful Supply Chain

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How do we obtain Real-time Information from the Stakeholders?

A web-based portal?

Information Source: https://www.slideshare.net/naseer9848/supply-chain-and-logistics-issues-of-crude-oil-in-india

Requirements of a Successful Supply Chain

- Minimization of material procurement
- [illegible] manuf[illegible]
- e[illegible]bers
- [illegible]
- lowest cost





How do we obtain Real-time Information from the Stakeholders?

What is the guarantee that the information submitted is correct?

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How do we obtain Real-time Information from the Stakeholders?

What is the guarantee that the information submitted is correct?

What if someone denies the information later on?

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Blockchain is the answer !!

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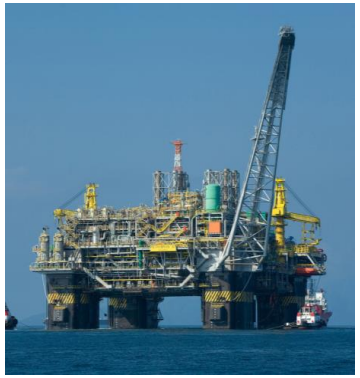
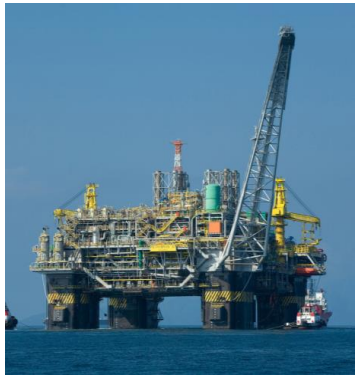
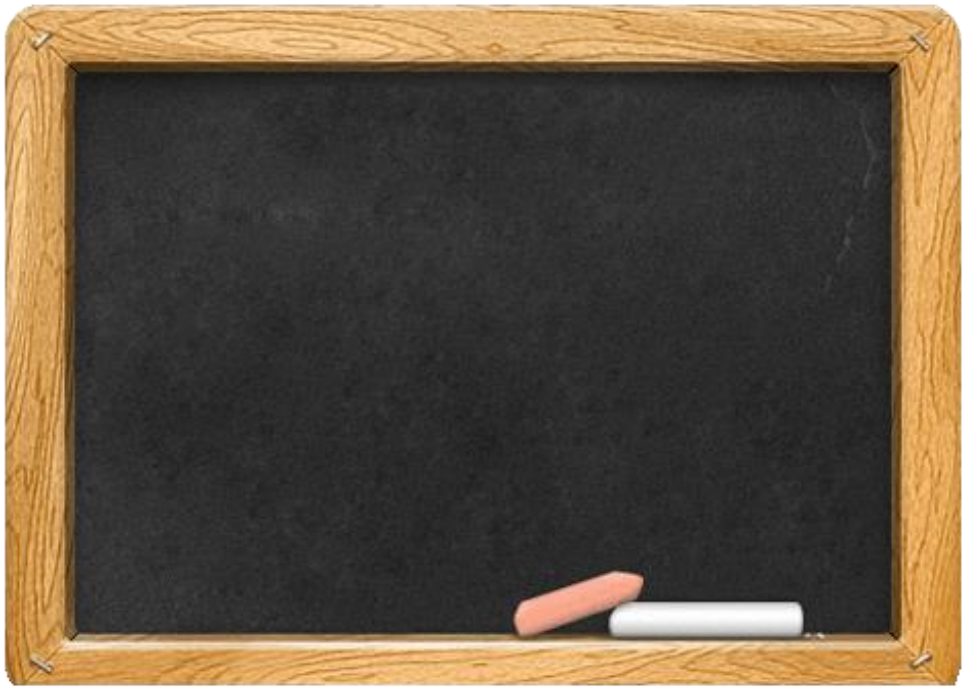
How Can We Obtain Real Time Information?



Use a Public Bulletin Board





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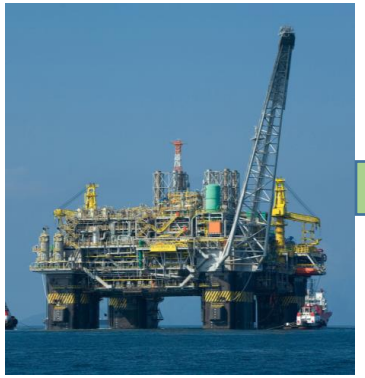

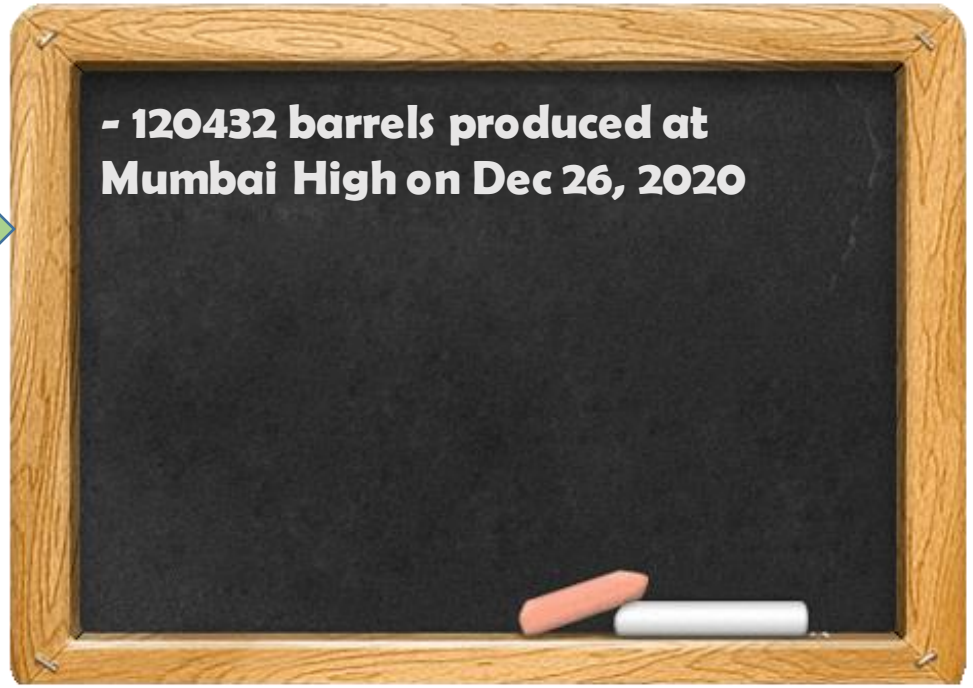

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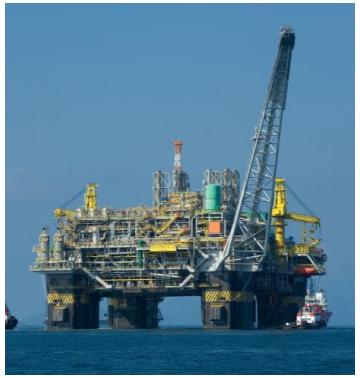

- 120432 barrels produced at Mumbai High on Dec 26, 2020
- 16467 barrels transported from Mumbai High to HPCL Refinery on Dec 26, 2020 at 2:30 pm

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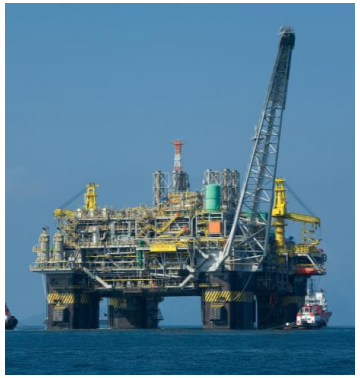

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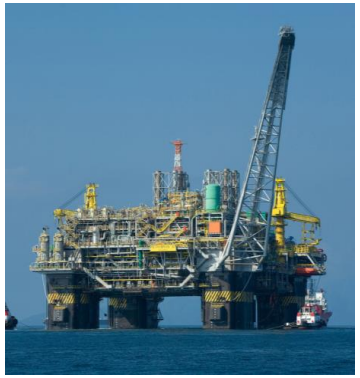
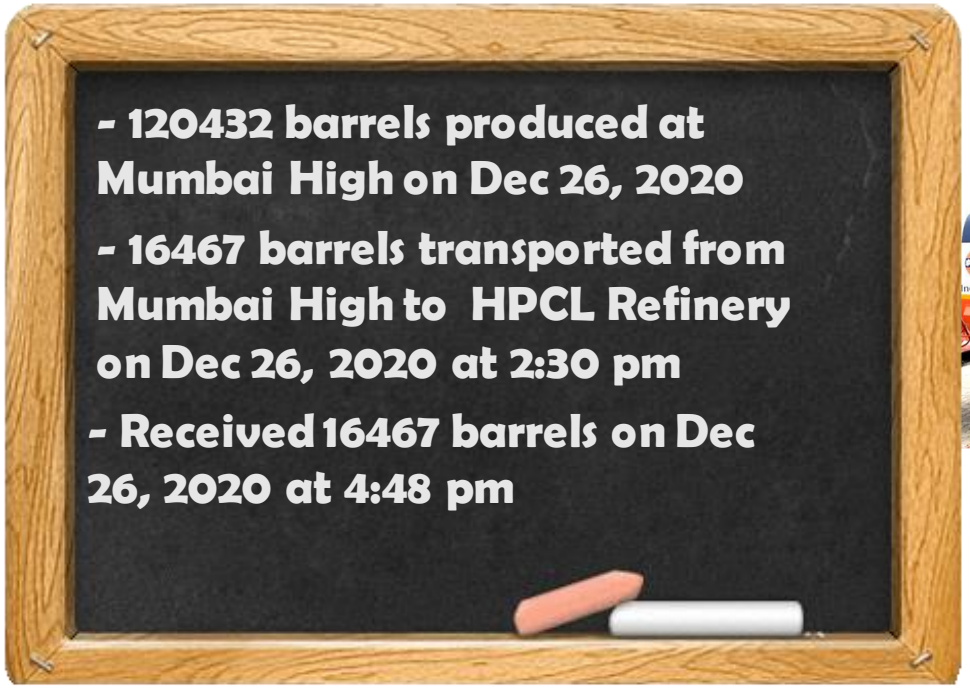
- Received 16467 barrels on Dec 26, 2020 at 4:48 pm

Use a Public Bulletin Board -- Advantages



- Everyone can see all the logs and verify



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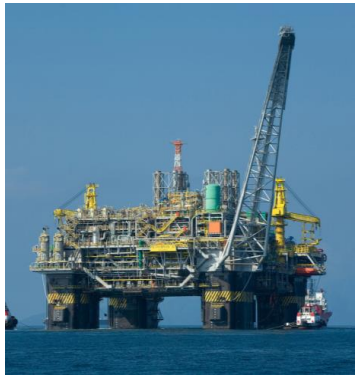
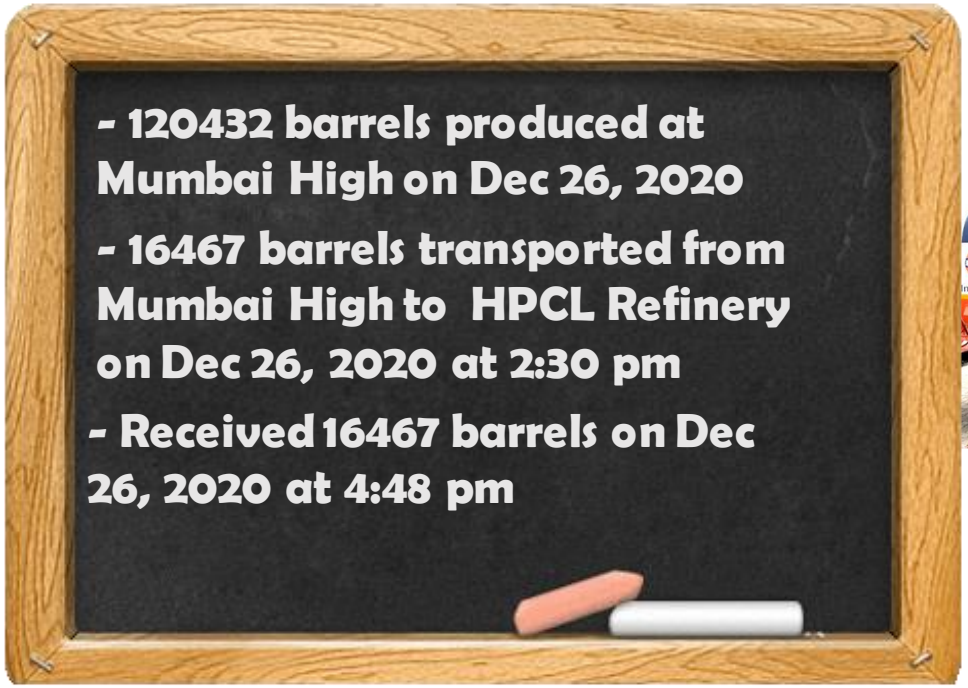


- **Any change in information is visible to everyone**



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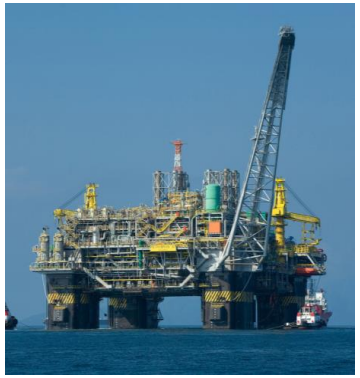
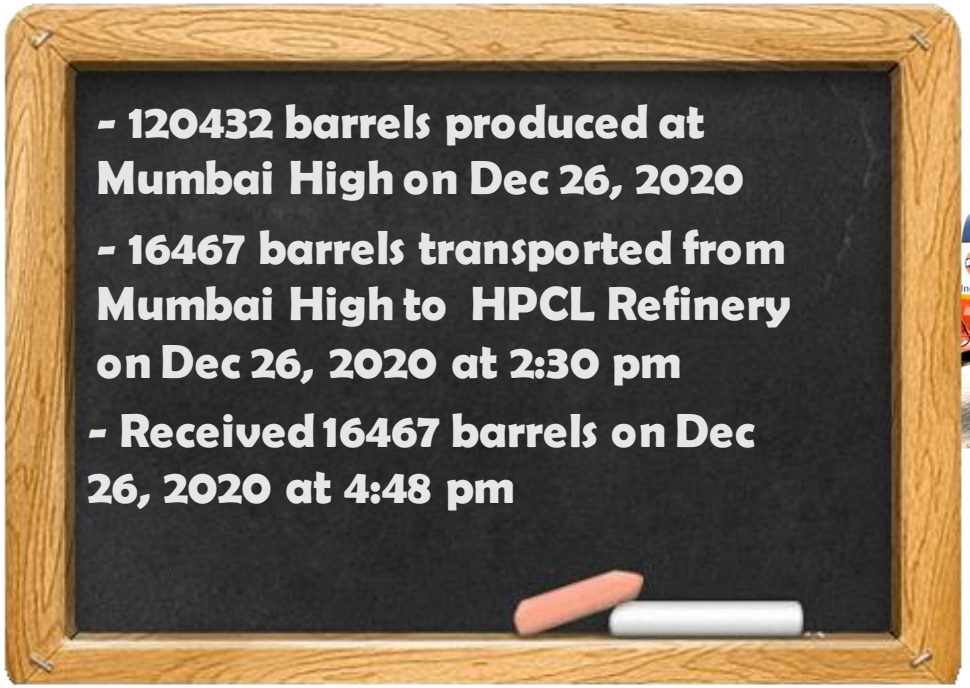


- **The board is not erasable, no one can deny later**



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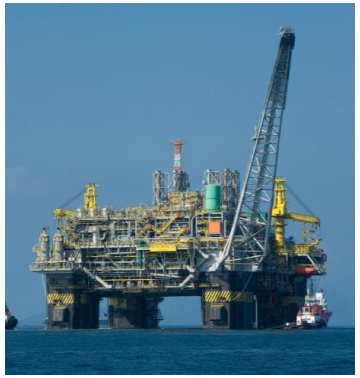

- **Simple one-step auditing**

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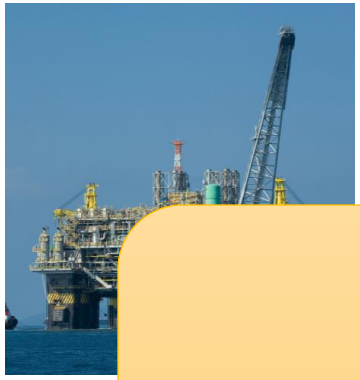
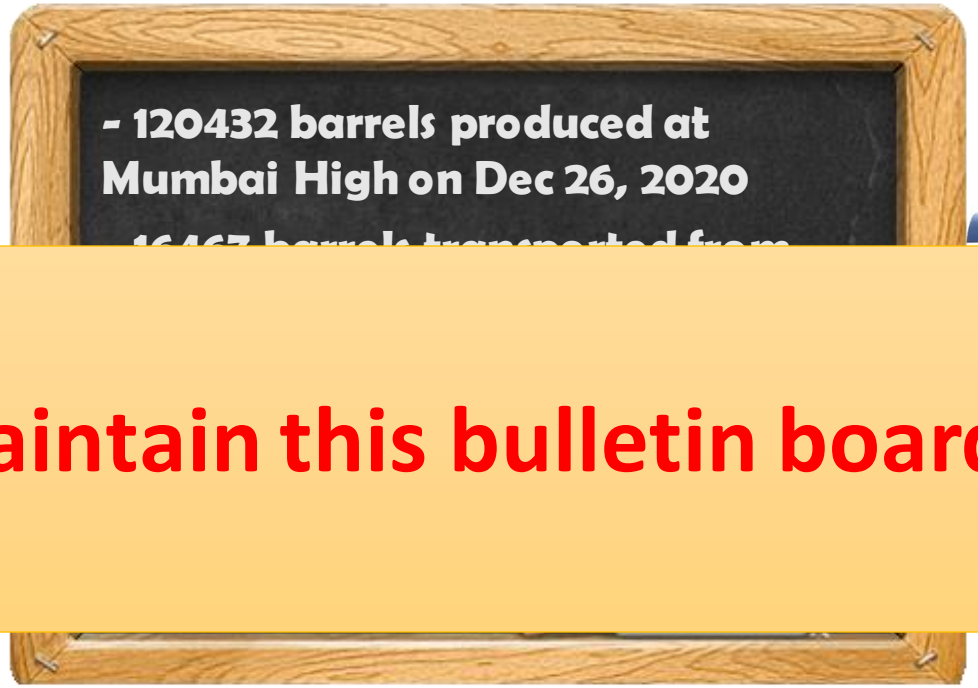
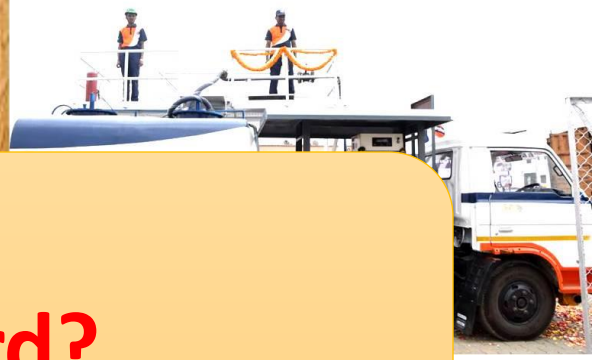
- Received 16467 barrels on Dec 26, 2020 at 4:48 pm

Use a Public Bulletin Board -- Challenges





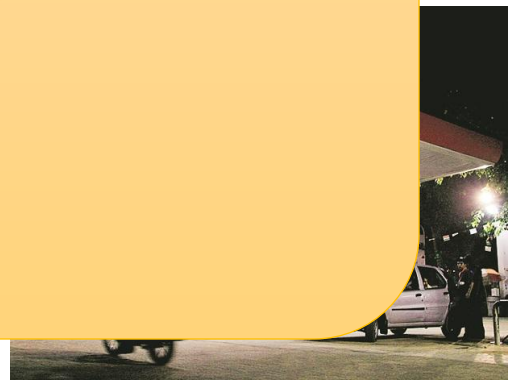


Who will maintain this bulletin board?

Use a Public Bulletin Board -- Challenges

Who will maintain this bulletin board?

- Buy Cloud from amazon



Use a Public Bulletin Board -- Challenges

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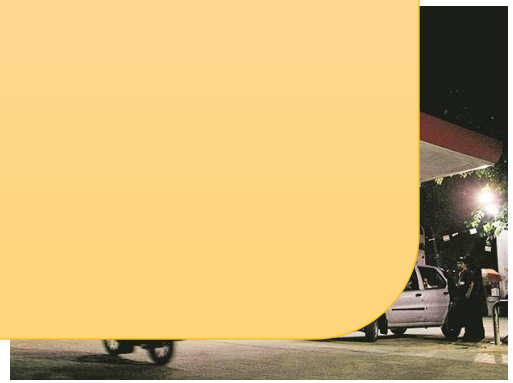
Who will manage it and provide the cost?



Use a Public Bulletin Board -- Challenges

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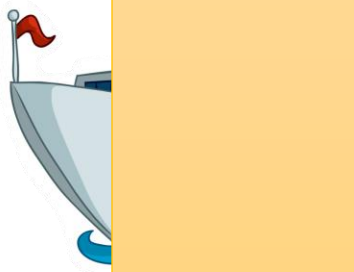
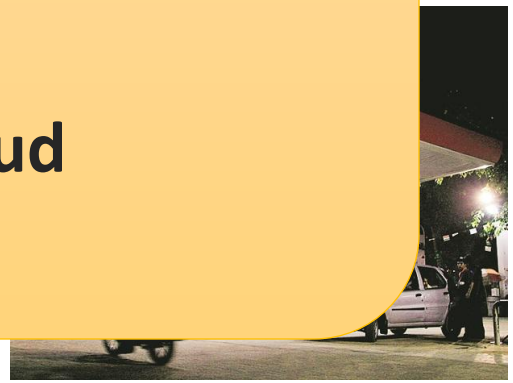
- One of the enterprises maintain a private cloud





Use a Public Bulletin Board -- Challenges

Who will maintain this bulletin board?

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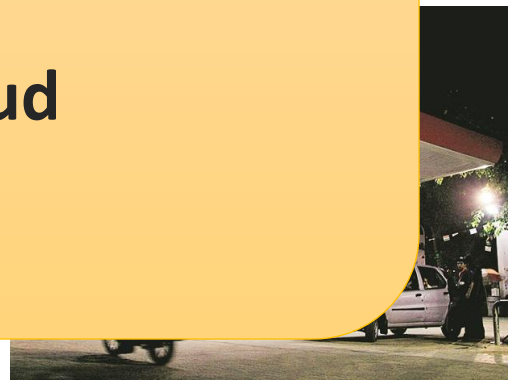
- One of the enterprises maintain a private cloud

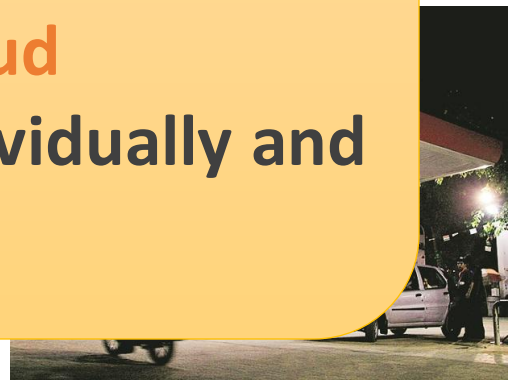
What is the guarantee that it is not a fraud?



Use a Public Bulletin Board -- Challenges

Who will maintain this bulletin board?

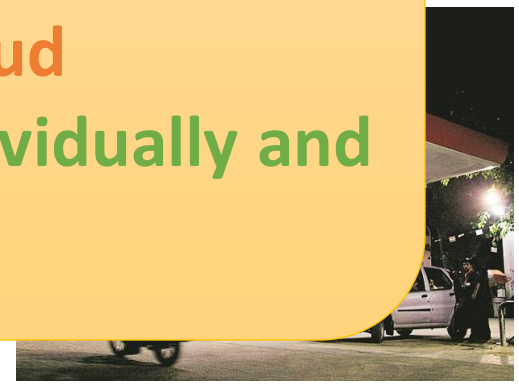
- Buy Cloud from amazon
- One of the enterprises maintain a private cloud
- Let everyone maintain the same copy of the board individually and independently



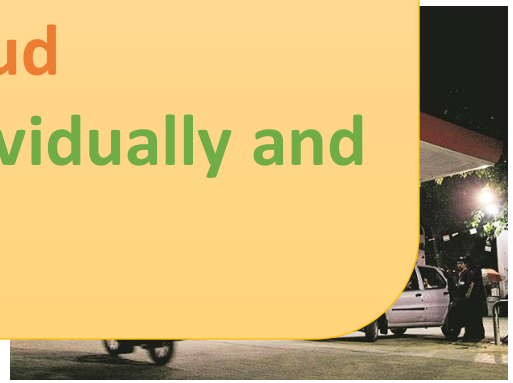
Use a Public Bulletin Board -- Challenges

Who will maintain this bulletin board?

- Buy Cloud from amazon
- One of the enterprises maintain a private cloud
- Let everyone maintain the same copy of the board individually and independently – **BUT HOW?**



Use a Public Bulletin Board -- Challenges



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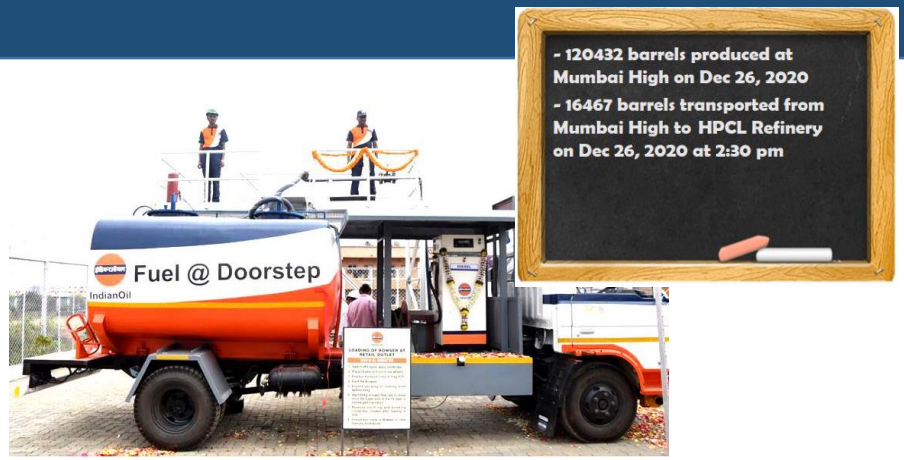
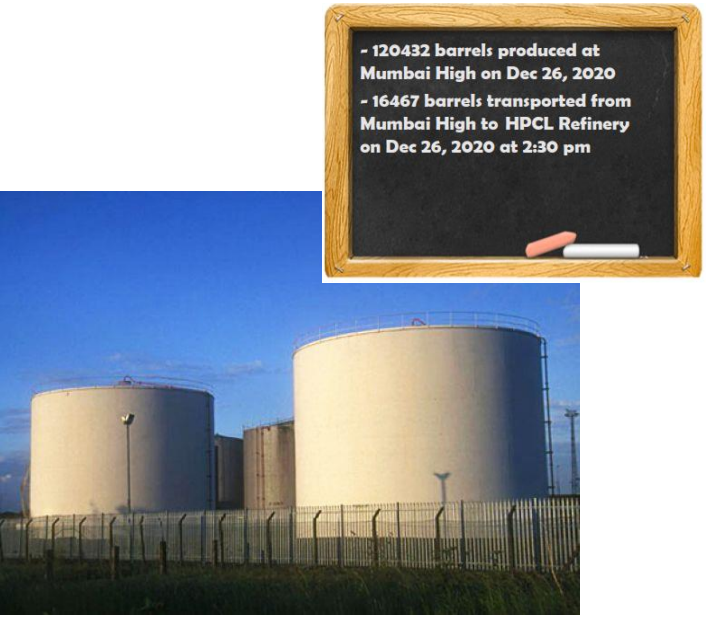
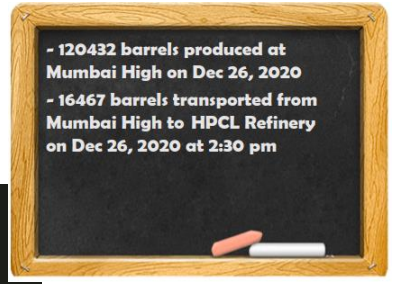
What is this “Blockchain”?

A decentralized and multi-authority networked information data storage and access system

What is this “Blockchain”?







No one is the sole-owner of the data, but everyone has a copy of the data - there is no central database

What is this “Blockchain”?

- 120432 barrels produced at Mumbai High on Dec 26, 2020
- 16467 barrels transported from Mumbai High to HPCL Refinery on Dec 26, 2020 at 2:30 pm

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Everyone holds exactly the same copy of the data at the same instance of the time

What is this “Blockchain”?

An immutable append-only ever-growing chain of data. Data once added cannot be deleted or modified later

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Once something is added in the blockchain, it cannot be denied later

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The information is transparent to all - everyone can see what is going on in the system

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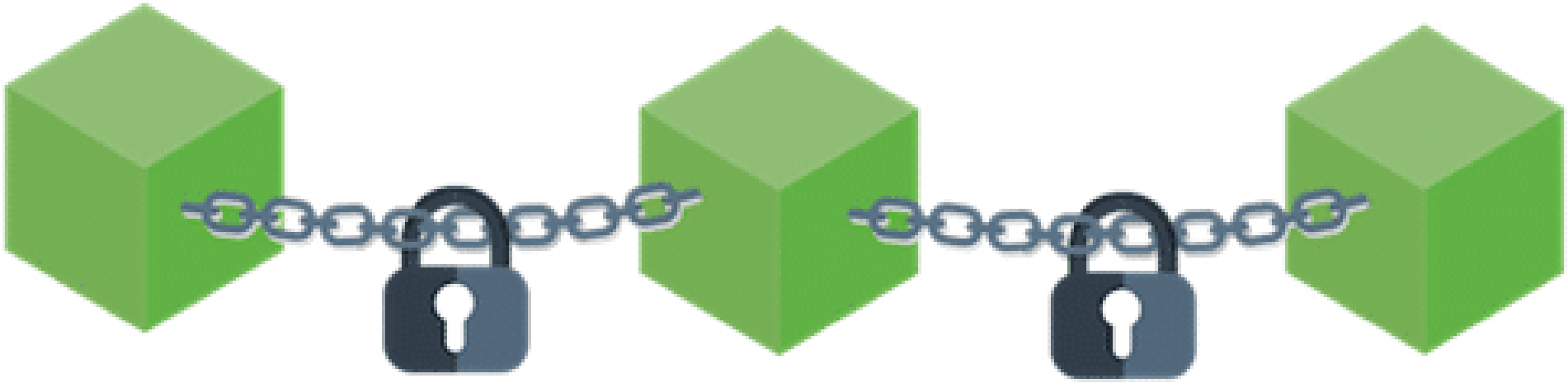
No-one can make any change without others to notice it



So, What Can be the Definition of a "Blockchain"

A decentralized immutable append-only public ledger

What's Next?

- Some basics of various crypto techniques
  - Cryptographic Hash
  - Public key cryptography
  - Digital Signature