HYPERLEDGER
BLOCKCHAIN TECHNOLOGIES FOR BUSINESS

## ABOUT HYPERLEDGER

**Hyperledger** is an open source effort created to advance cross-industry blockchain technologies. It is a global collaboration including leaders in banking, finance, Internet of Things, manufacturing, supply chains, and technology. The Linux Foundation, the nonprofit organization enabling mass innovation through open source, hosts Hyperledger. The Linux Foundation also enables a worldwide developer community to work together and share ideas, infrastructure, and code.

LFNETWORKING

## ABOUT LF NETWORKING

**LF Networking (LFN)** brings together eight top networking projects to increase harmonization across platforms, communities, and ecosystems. The LFN projects address major industry challenges — and through collaboration between end users, vendors, and developers — are transforming all aspects of the network and accelerating open source deployments.

# Optimizing Wholesale Intercarrier Settlement with Hyperledger Fabric Blockchain

## Purpose of this Solution Brief

This document describes how a blockchain-based solution can help telecommunication service providers invoice and settle cross-charging payments more quickly and efficiently. This brief also defines a Minimum Viable Product (MVP) for this solution and proposes a consortium of wholesale operators that could use this solution to dramatically streamline the settlements process.

## Intended Audience

The primary audience for this solution brief is network operators who are interested in reducing the cost of cross-charging settlements. This document will also interest technical people who would like to explore blockchain technology by implementing a real use case.

## A Collaboration

This solution brief was driven by the **Hyperledger Telecom Special Interest Group**, a collaboration with LF Networking and its associated projects that explores use cases for blockchain technology in the Telecom industry.

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# 1. Introduction

This solution brief describes the problems with the current methods that telecom network operators use to settle invoices between themselves. This brief proposes a new approach based on Hyperledger blockchain technology that can make this process far more efficient and cost-effective.

### 1.1 The Interconnect Problem

Telecom network operators around the world open their networks to each other to enable their customers to communicate across network boundaries. This practice is known as **interconnect**. This is used throughout the industry among national and international operators for fixed, mobile, and Internet services.

Network operators cross-charge one another for the interconnect services they offer one another's customers. This is done through a process of invoicing (billing) and settlements, based on the records that operators are supposed to store about every call ever attempted, whether or not the call is completed.

These records are known as **Call Detail Records (CDRs)**. Among other details, a typical CDR includes:

- Calling and called party's phone numbers
- Duration of the call
- ID of the equipment that handled the call
- Result of the call
- Timestamp for each activity
- Unique CDR ID

Interconnect partners share invoices based on the agreed billing cycles. These invoices are then reconciled with the billing system records. In case of any discrepancy, the next step is to reconcile the CDRs to verify any cross-charges, volume mismatches, or fraudulent transactions. But this verification process is costly, cumbersome, inefficient, lengthy, and prone to errors. For example, missing CDRs and discrepancies in CDRs are common problems.

Due to the large number of network operators in the world and the many-to-many relationships among them, the volume and complexity of cross-charging and settlements data is growing exponentially.

Typically, wholesale interconnect contributes 30% to 40% to the overall business of a teleco. But declining margins make it essential to solve the problem of revenue blocked due to disputes and to contain the high costs involved in resolving discrepancies.

These problems are not limited to interconnect; they affect the entire wholesale domain including roaming.

Here's one example of how cumbersome this process can be. To settle roaming charges, mobile operators check international Data Clearing Houses (DCHs) to validate roaming fees, and then cross-reference the data against the information provided by Financial Clearing Houses (FCHs). FCHs are used for debt collection rates and clearing accuracy. Access to DCH and FCH data is slow, and the data gathered often contains errors.

Network operators spend substantial amounts of money for settlement services from the clearinghouses and to fix data errors to reconcile their records and books. And for many telecom operators, interconnect is their only business that is bought and sold wholesale.

Traditional partners conduct this wholesale business. Even though these partners are known to each other, problems often emerge from these partnerships, including:

- Long contract timelines
- Long settlement processes
- Disputes due to data mismatches
- Revenue blocked during any disputes
- Wholesale fraud

In most cases, billing discrepancies are honest mistakes. But mistakes can sometimes be malicious, with the intent to block payments or renegotiate payables. Even the most common disputes can take several months to resolve. And in some cases, the operator must compromise and write off the disputed amount.

The root of the problem lies in the way transactions are controlled between partners. Since both parties maintain records with a centralized, siloed approach, there is little transparency. This leads to lack of trust. And since traditional centralized databases are generally not encrypted, there is always a risk of an operator's sensitive data about a partner's customers being lost, exposed, or manipulated.

Table 1 shows a simple example of the issues between interconnect partners. This table is based on interviews with network operators and the working knowledge of the Hyperledger Telecom SIG members about the industry's practices for wholesale settlement.

**TABLE 1: SOME TYPICAL ISSUES IN NETWORK INTERCONNECT**

| ITEM | TIMING or NOTE |
|---|---|
| Billing cycle | Monthly |
| Bill generation and distribution | 5th day of the month |
| Bill reconciliation | 2 or 3 days |
| Dispute identification and confirmation | 15 to 45 days |
| CDR reconciliation process | 90 to 180 days |
| Added delay for fraud disputes | The operator does not discover any fraudulent transactions until the reconciliation process. |
| Dispute analysis and resolution by partner | Months to years |
| Results of disputes | During dispute: receivables blocked<br>If unresolved: receivables written off |

Note that to start a dispute investigation, one partner must send the other a dispute claim form that lists the disputed destinations, volumes, and rates. In some countries, starting a dispute over fraudulent transactions requires a police report. But a police report may not be acceptable to a partner because of missing information, unreliable format, or other issues.

This shows how time-consuming the industry's traditional way of handling settlements has become. This approach also causes serious financial issues including excessive overhead, exposure to fraud in remote jurisdictions, and blocked or lost revenue because of unpaid bills.

For all these reasons, this interconnect problem is now one of the most vocal concerns being raised by wholesale operators.

### 1.2 Highlights of a Blockchain Solution

Many network operators and telecom companies are wondering if blockchain technology could be a solution to their interconnect billing and settlement headaches. Could certified charging data be stored on the blockchain, eliminating the need for third parties and the tedious process of settlement?

We believe the answer is yes. A blockchain-based solution can dramatically streamline interconnect cross-charging and billing, solve data delays and problems, and save time and money for every operator. Here's how.

**Instant access to reliable call data on the blockchain:** Network operators can store CDR data for interconnect cross-charging on the blockchain in real-time. All operators anywhere in the world can have instant access to this data, without being able to modify it.

**A single source of truth that eliminates siloed processes:** When the blockchain ledger becomes the single source of truth, this enables network operators to access and verify billing and cross-charging data in real-time. This eliminates the need for each operator to perform their own siloed process of reconciliation, which makes settlement far simpler and more reliable. This also helps to prevent fraud by identifying it much earlier in the billing process.

**Smart contracts that automate agreements:** Network operators routinely dedicate resources to negotiate interconnect charges and clearing agreements with other operators. After an agreement is reached, it is scripted and governed by regulations. Then a smart contract can be used to execute these agreements reliably and objectively.

**A private, permissioned blockchain that protects confidential data:** The direct beneficiaries of any blockchain-based solution are the network operators that make up a business network, consortium, or closed ecosystem. These members have formal legal relationships and share a certain level of trust, but not absolute trust.

For example, not all CDR data should be accessible to all. Only the network operators and their partners with interconnect or roaming agreements should be able to access data on their mutual customers. And CDR records contain private customer information that should not be open to the public.

All this makes a permissioned enterprise-caliber blockchain—such as one of the frameworks available from Hyperledger—more suitable than a permissionless public blockchain. A permissioned blockchain can reflect the relationships among network operators and allow for controlled access to information on the ledger.

**Automation that streamlines a digital process:** Except for the human interaction during negotiations and disputes, interconnect falls in the digital space. Basically, once two partners reach an agreement about interconnect charges and billing terms and conditions, all the ensuing data generation, storage, and verification can be done automatically by the blockchain network.

**Governance that builds trust:** In general, telecom network equipment manufacturers certify CDR data. However, there is no guarantee that some network operators won't ever try to manipulate CDR data to their advantage before writing it on the blockchain.

The solution is to establish a blockchain governance process that can ensure data provenance and veracity. This solves any issue of limited trust between partners by building trust into the blockchain code, the network consensus mechanism, and the policies for governing the consortium. Any partner who tries to break that trust can be found out, disciplined, or even expelled from the network.

### 1.3 Solution Essentials

Here are some "must-have" capabilities for a blockchain solution to the interconnect problem:

- Gain better visibility with partners with interconnect agreements
- Build transparency and trust across deals and financial transactions
- Ensure financial and legal compliance in all transactions
- Increase direct control by reducing the need for intermediaries
- Eliminate concerns around data or transaction manipulation

## 2. Why Use Hyperledger Fabric for This Solution?

Any network operators that partner for wholesale interconnect with agreed-on rates—either through rate card exchange, or bulk deal contracts—are known entities to one another. The problem is not about trust; these operators have already agreed to do business.

The problem is the fragmented processes that delay settlements and block receivables. When trusted entities interact, an enterprise-grade blockchain is the best fit. It's vital to find the right platform that can integrate with existing billing solutions.

The best platform must deliver all the capabilities of blockchain to make interconnect processes seamless and transparent. Table 2 shows the essential requirements for a blockchain solution to the interconnect problem.

**TABLE 2: ESSENTIAL REQUIREMENTS FOR A BLOCKCHAIN SOLUTION**

| REQUIREMENT | WHY NEEDED |
|---|---|
| Data privacy | CDR data is private and confidential, and only partners should have access to data on mutual customers |
| High throughput | A huge volume of transactions is common in the wholesale interconnect business |
| Cost-effective solution | Network operators do not want to drive up the Total Cost of Ownership (TCO) |
| Open source technologies | More transparency, faster time-to-market, no vendor lock-in, cost-effective development |

Considering these requirements, the Hyperledger Fabric framework seems to be the best fit due to the following capabilities:

- An open-source platform governed by the Linux Foundation with the goal to redefine trust on the Internet.
- Well-defined roadmap that ensures the addition of new capabilities.
- Dedicated worldwide community with more than 270 members for long-term project support and timely closure of any issues.
- Proven track record of successful PoCs and production systems in various domains.
- Designed for enterprises seeking to build permissioned blockchain solutions, where only known and allowed entities can belong to the network.
- Many interconnect partners can be hosted at once by creating partitioned channels that enable coexistence and at the same time maintain strict data privacy.
- No need for public miners because the built-in Orderer handles consensus.
- No need for any cryptocurrency, making the permissioned blockchain acceptable to regulatory bodies across geographies.
- Based on performance tests, Hyperledger Fabric has delivered a good number of transactions per second (TPS). In a study at Cornell University, the framework achieved throughput of 20,000 TPS.[1] A recent test by IBM recorded 13,000 TPS.[2]

All these capabilities look promising and make Hyperledger Fabric suitable for the wholesale interconnect use case.

Note that another blockchain framework from Hyperledger or elsewhere might well be suitable for designing and building this system. We selected Hyperledger Fabric because it met all the criteria listed above and we were already familiar with it. The solution is designed to support different distributed ledger platforms through plug-ins.

## 3. Business Architecture

The proposed solution will complement an operator's legacy OSS/BSS systems by enabling blockchain-based settlement. This will drastically streamline the dispute management and settlement processes.

The proposed architecture provides all the key functions that form the basis of a blockchain-based settlement solution. The solution includes an event-agnostic platform that can manage settlement for Content, IoT, Roaming, SMS, Voice, or any other event settlement scenario. This makes it a true convergent approach.

Since not all operators may form a single consortium, different operators will likely be using different technologies. This solution will support multiple distributed ledger technologies (DLTs). However, Hyperledger Fabric will be the primary platform for the proposed solution due to its enterprise-grade DLT and all the other factors listed above.

In the preferred reconciliation approach, CDRs will be aggregated based on an acceptable interval for reconciliation. This will reduce the performance-related bottlenecks that are a known challenge with DLTs.

The Hyperledger Telecom Special Interest Group (SIG) is actively researching the available techniques for gaining better throughput. The SIG is committed to working with operators to build a solution that can reconcile for billions of wholesale records at the CDR level across multiple traffic streams including Broadband, Content, IoT/M2M, MEC, Roaming, and Voice.

Figure 1 shows the business architecture of the proposed solution.

At the top are the legacy OSS/BSS systems. Operators A through D are shown, but many more could belong to the network, up to number *N*. Each partner has access to the system through a Web portal. A set of open APIs and collection services provide various functions to support the business.

At the foundation, the blockchain provides a single source of truth for all CDRs. Hyperledger Fabric is the default blockchain that enables, for example, operators A and B to settle disputes by referring to the blockchain.

The solution also provides plug-in support for other DLTs. Thus if operator C is using an Ethereum-based system, operator A could still manage and settle disputes with operator C, thanks to the interoperability designed into the system.

Each specific module is described in the next section.

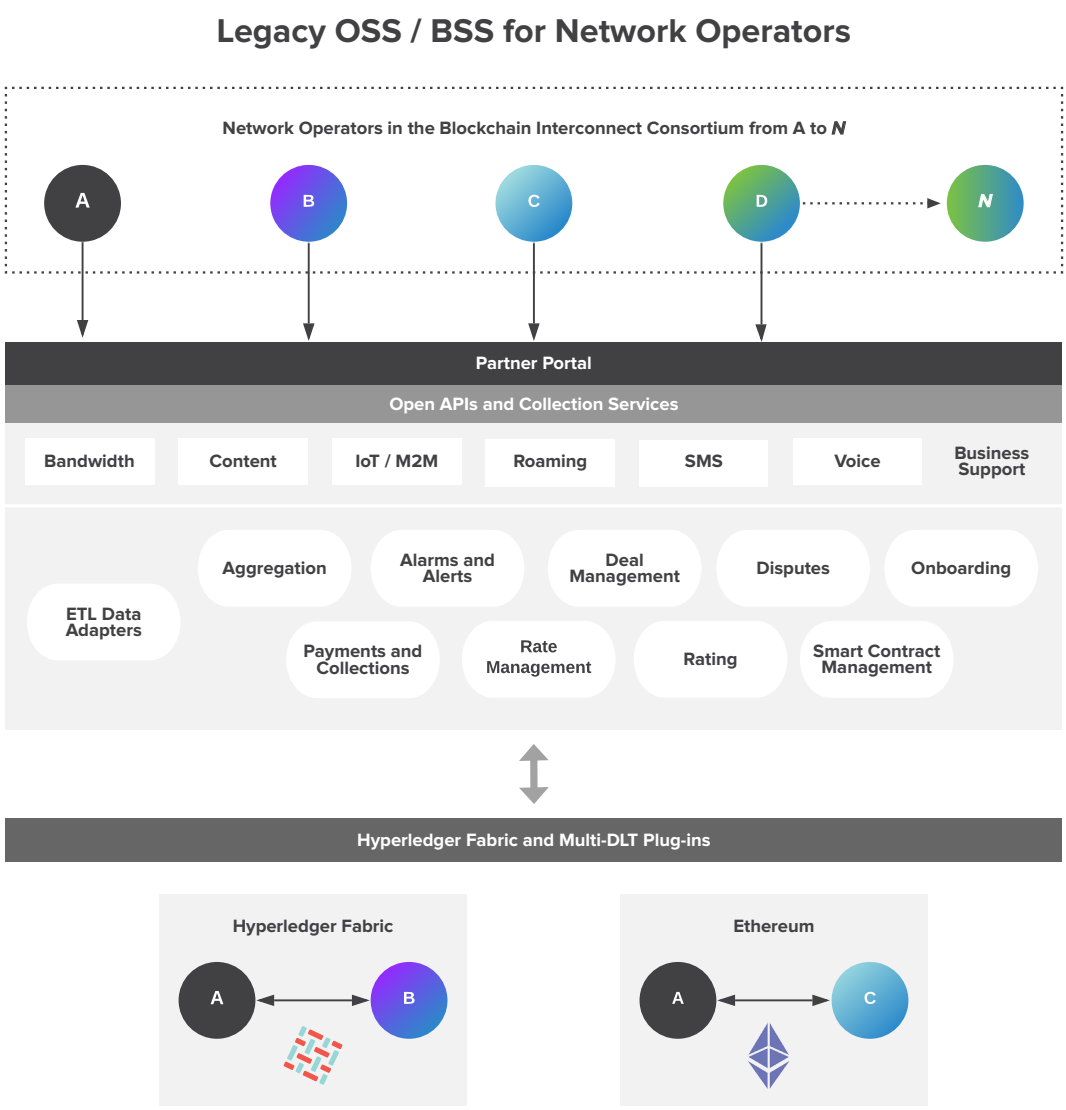


**FIGURE 1: BUSINESS ARCHITECTURE OF THE BLOCKCHAIN SOLUTION**

## 4. Module Description

This section describes each module of the business architecture shown in Figure 1, starting from the top. The collection services are listed in alphabetical order.

### 4.1 Partner Portal

The Partner Portal is the key interface for all participants in the consortium, which provides the solution's self-service capabilities. Several important features that will be enabled in the Partner Portal are:

- Bilateral smart contract creation
- Disputes management
- Payment and collections
- Reconciliation reports and dashboards including discrepancies
- Self-onboarding for new partners
- Upload rate sheets to record on the blockchain

### 4.2 Extract Transform Load (ETL) Data Adapters

The ETL layer provides a way to map the CDR input data and translate it into an output format appropriate for the billing and settlement process.

The ETL consists of three main capabilities:

- Decoding—Parse incoming data format, and create output data formats
- Mapping—Translate decoded input data into one or more output data types, including filtering and enrichment
- Operational Control—Configure data sources, collection schedules, and run-time environment management

### 4.3 Open APIs and Collection Services

The proposed solution will come with a library of REST APIs that will act as a middle layer to enable integration of existing legacy systems with the new blockchain-based settlement system. Here are some of the key APIs:

- Create Account
- Create Account Profile
- Collections
- Deal Creation
- Dispute Creation
- Payment

Collection services will gather CDRs and rate sheets from operators. The rate sheets will be stored as hash values that can be produced in case of rate disputes. Collection services will supply CDRs to the ETL module for aggregation and normalization.

### 4.4 Aggregation

The rated records will undergo an aggregation process which summarizes the CDRs for a configurable interval (hourly, daily, or other). Every channel requires an aggregation interval. Both partners on the same channel should use the same interval for faster reconciliation. Operators using multiple channels can configure a different interval for each channel, as long as their partner in each channel uses the same setting.

### 4.5 Alarms and Alerts

The solution will come with a range of predefined alerts to notify partners of any reconciliation discrepancies.

### 4.6 Deal Management

Through a user-friendly graphical interface, the solution will support many different types of agreements, such as back to first minute, balanced deals, committed, tiered, and so on. A deal can be set up in various ways. For example, a partner can configure the deal through a smart contract template available via the Partner Portal. Or the deal information can be shared over an API.

Deal data will be written in the ledger once there is a consensus between the partners that the deal is accepted. The deal document hash can also be maintained in the ledger for future reference to resolve any rate and volume discrepancies.

### 4.10 Disputes

Dispute management can be achieved directly from the Partner Portal, or by exposing the key APIs to create and manage disputes in legacy solutions. The objective of the blockchain solution is to have minimal disputes. But any discrepancies due to fraud, rates, or volume should be handled with a structured dispute management process.

### 4.11 Onboarding

The Onboarding service will be a workflow-based module used to add new organizations to the blockchain and to create different channels that enable the settlement services.

An administrator can make a request and the system will create a workflow to approve the channel and peer creation. Based on the selected partnerships from the consortium list, the system will enable automatic channel creation between the parties involved.

A new user of a Partner Portal can be created and enabled with Onboarding. And other account management activities like enabling and disabling organizations and channels can be handled with this module.

### 4.12 Payments and Collections

The Payments and Collection module will support the incoming and outgoing transactions logged against invoices. This module will capture payments and collections either by integrating over APIs or by logging with the screen options.

### 4.13 Rate Management

Once the rates are uploaded and the other party authorizes those rates, a consensus is established, and the rate entries will be created in the ledger. The rate sheet file can also be maintained with hash values for future reference in case of any rate discrepancies.

### 4.14 Rating

In this module, input CDRs will be matched against partner reference configurations in the system and then rated based on the price for corresponding services. Smart contracts will be created that can pick the agreed rates from rate sheets and deals. After the partner consensus is achieved, the smart contract will rate CDRs based on the rates logged in the ledger. This approach should entirely avoid any rate disputes.

For legacy billing solutions, this process can be optional. In these cases, the recommended approach will be to use rated records from partners in the consortium for reconciliation.

### 4.15 Smart Contract Management

The Smart Contract Manager will enable operators to track any existing contracts that are live and any new contracts in either draft or testing. Through this module, an operator can see the history of the contract execution, the status of execution, and the various organizations and peers the contract was run for.

The administrator view of the Smart Contract Manager will also show which APIs the smart contract triggered to perform business tasks. All this information will be useful when auditing the smart contract's performance.

## 5. Technical Architecture

This section describes the highlights of the technical architecture of the proposed blockchain solution, as shown in Figure 2.

### 5.1 Middle Layer

The middle layer stack interfaces with legacy OSS/BSS systems to receive the input data using APIs for various purposes. Data normalization and preprocessing is done in the middle layer and the data is then passed down to the Hyperledger Fabric blockchain network. A multi-DLT scenario could be handled using plug-ins to facilitate communication between the middle layer and the blockchain networks.

### 5.2 Blockchain Network

The parties doing governance of the Hyperledger Fabric network will be able to define the network, add/remove participants, provide roles and privileges, create/modify/delete channels, and so on.

The Hyperledger Fabric network will include multiple organizations, each representing a **collaborating operator (CSP)**. The operators involved in the wholesale settlement process will be added to the Hyperledger Fabric network. Each pair of operators will communicate with each other via a separate channel. This ensures that the data from their mutual customers is available only to the participating operators and not to any other operator.

For example, let's say CSP1 and CSP2 communicate with each other via channel1 while CSP3 and CSP4 communicate with each other via channel2. This means that neither CSP1 nor CSP2 can retrieve or tamper with any data pertaining to CSP3 or CSP4, and vice versa. This ensures a secure channel of communication.

### 5.3 Entities in the Blockchain Network

The Hyperledger Fabric network will include several different entities, each with a distinct role to perform, as follows.

There must be at least one ledger per channel to record each transaction. These ledgers will be in sync across all the general peers of all organizations on a single channel. This ensures that data is distributed across multiple ledgers to maintain integrity.

There will be at least one smart contract per channel to write to the corresponding ledger. The smart contract, also known as "chaincode" in Hyperledger Fabric, will include custom logic to perform the required operations for wholesale settlement. The aggregated CDR entries will be reconciled, and the required output will be written to the ledger to record a transaction.

There will be several types of peers on the network:

- The Anchor peer will be responsible for communications between different organizations via a channel.

- The Endorsing peer will run a smart contract.
- The Orderer peer will be responsible for ordering the transactions before they are validated and committed to the ledger by the Committing peer.

Note that any peer can be located either on the operator's premises or provisioned in the cloud to minimize complexity.

### 5.4 Flow of transactions

The CDRs of the participating operators will be picked by the middle layer, normalized and aggregated, and then fed to the Hyperledger Fabric network. The partners who are the source and destination of any CDRs will be connected to each other via a dedicated channel. Only the partners involved in CDRs for mutual customers will belong to any channel. No participants on the blockchain network will be able to communicate with those who take part through another channel.

The consensus to make a transaction successful includes these steps:

- Endorsement from the partners (done by the Endorsing peer)
- Ordering the transactions (done by the Orderer node)
- Validating transactions and then committing valid transactions to the ledger (done by the Committing or general peer)

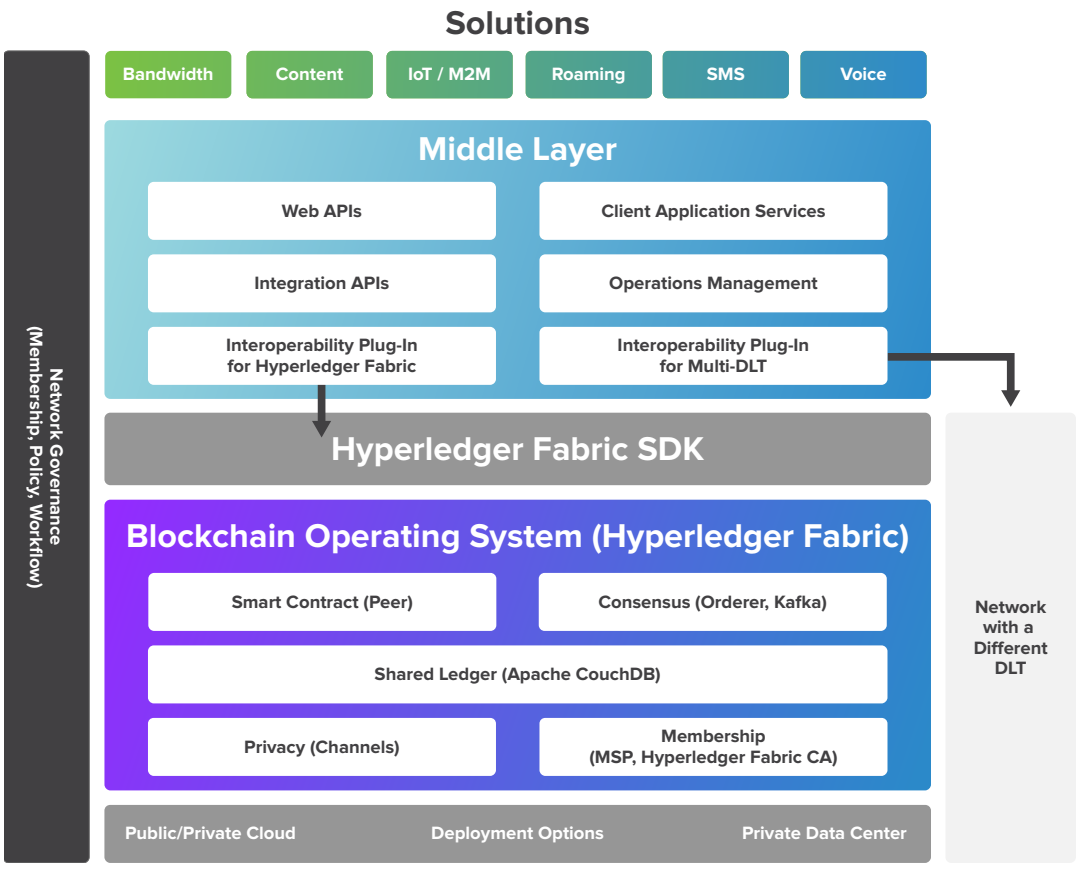


**FIGURE 2: TECHNICAL ARCHITECTURE OF THE BLOCKCHAIN SOLUTION**

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## 6. Hardware Sizing

This section describes the hardware sizing considerations for the proposed blockchain solution. Table 3 lists the minimum recommended number of nodes of each type for an effective proof of concept. Figure 3 shows a visual representation of how these nodes should be allocated in a single channel with two partner organizations. This hardware sizing would be required for the MVP, though the number of peer nodes could differ based on the actual load and transaction rate.

**TABLE 3: ESSENTIAL REQUIREMENTS FOR A BLOCKCHAIN SOLUTION**

| NODE | MINIMUM RECOMMENDED | BENEFIT |
|---|---|---|
| Anchor peer | 1 per organization | Will facilitate the connection between organizations in the channel |
| Committing peer | 2 per organization | Will facilitate the availability of the distributed ledger |
| Endorsing peer | 1 per smart contract per organization | Will enable higher performance if multiple smart contracts run in parallel, without affecting endorsement |
| Orderer | 1 per channel | Will help order messages so they are sent to connected peers in the same order |

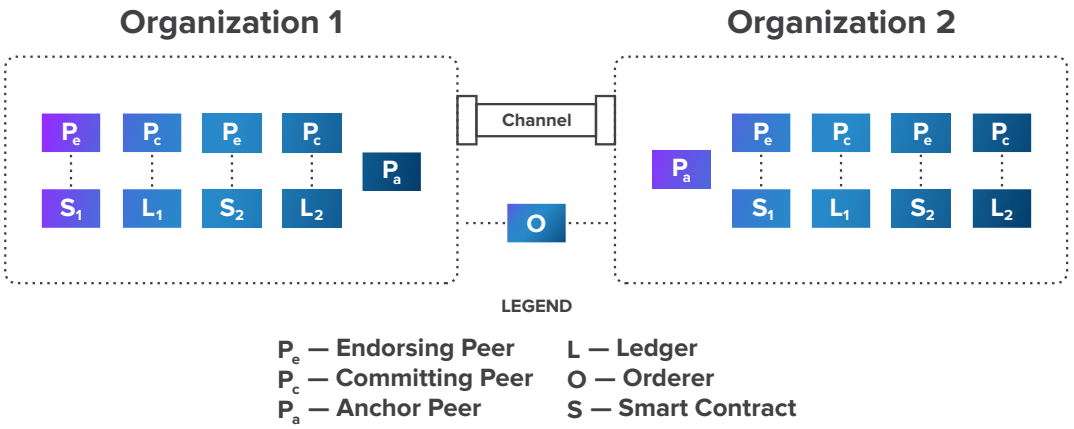


**FIGURE 3: NODE ALLOCATION FOR TWO PARTNERS ON A CHANNEL**

## 7. Blockchain Challenges

Blockchain brings in the concepts of consensus, privacy, security, and trust. All of these can help address some of the key challenges of today's interconnect settlements. In today's dynamic business landscape, telecom companies can leverage this emerging technology to make a difference with their new and existing partners.

Since blockchain technology is still in its early days, it offers both promising capabilities and its own set of challenges. The Hyperledger Telecom SIG is actively working with operators, vendors, and researchers to solve the following challenges:

**Business challenges**—Some of the use cases we've identified deal with wholesale disputes and invoice reconciliation. The question is, how can we define these use cases and integrate them with multi-DLT technology to deliver better results?

**Performance challenges**—Current wholesale partnerships between any two operators can amount to millions of transactions per day. And this workload will rise as we move to IoT and M2M scenarios with 5G becoming mainstream.

The Hyperledger Telecom SIG is committed to work with the technical community to build a blockchain-based solution that goes beyond simply providing expected high performance to optimize resources and deliver cost-effective solutions.

**Interoperability challenges**—Another challenge of blockchain is interoperability between different DLT platforms. Blockchain is most effective when used by a consortium, but it's not practical to limit every member to one DLT platform alone.

## 8. Next Steps (Proposal)

This solution brief shows the intention of the Hyperledger Telecom SIG to improve traditional reconciliation, bringing automation and simplification to this process. The scope, details, call flows, and development roadmap are subject to discussion and consensus within the group.

The next steps are to develop a PoC demonstrating a solution to the interconnect settlement use case, and to form an operator consortium.

To find out more or to join the Hyperledger Telecom SIG, visit **wiki.hyperledger.org/TCSIG/**

## 9. Conclusions

Decentralization is at the heart of blockchain and DLT. This is also the key enabler of disintermediation, the economic driver behind the adoption of DLT across many industries, including telecommunications.

Inefficiencies in the inter-carrier settlement process are well-documented and well-understood in the industry. Over the years, network operators have lost billions of dollars due to disputes over billing, data discrepancies and mismatches, and delayed revenue recognition.

This brief explained the interconnect settlement problem and proposed a solution based on the Hyperledger Fabric blockchain framework. This solution will simplify the settlement process by creating a trusted single source of truth for the CDRs generated by operators. This will eliminate the root cause of data mismatches and discrepancies.

The proposed solution focused on a set of core functions that will allow operators to reduce friction, time, and costs while maintaining autonomy, integrity, privacy, and control over their own data. The level of detail discussed in this solution brief is sufficient for implementing an MVP to demonstrate the core promises of the solution. These promises include simplifying and expediting the invoicing and settlement processes across multiple carriers.

The objective of the Hyperledger Telecom SIG is to form a global consortium representing network operators, billing and settlement vendors, and technologists to realize the proposed solution. We would like to showcase the solution at the global stage, and then improve it further into a commercial-grade system ready to be adopted by carriers around the world.

## Acknowledgements

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## Notes

1. Christian Gorenflo, Stephen Lee, Lukasz Golab, S. Keshav. “FastFabric: Scaling Hyperledger Fabric to 20,000 Transactions per Second.” v2, 4 March 2019. Retrieved from **https://arxiv.org/abs/1901.00910**

2. Christopher Ferris. “Does Hyperledger Fabric Perform at Scale?” Blockchain Pulse: IBM Blockchain Blog. 2 April 2019. Retrieved from **https://www.ibm.com/blogs/blockchain/2019/04/does-hyperledger-fabric-perform-at-scale/**