Restcomm

Restcomm Blockchain: Open Request for Comments

Empowering Business Communications by Decentralization and Disintermediation

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Disclaimer

This is a conceptual document describing a hypothetical blockchain protocol and token designed to enhance the Restcomm communications platform and its ecosystem.

1. Summary

Blockchain technology has ushered in a whole new culture in software and systems development and management. In the beginning, software systems were proprietary products. Eventually, some moved on to become open source. With blockchain technology, developers are not only contributors to software. Many of them help run the network by standing up nodes, supporting mining, governing token utilization, executing smart contracts and decentralized apps. More importantly, developers also propose and author improvements and changes to the blockchain protocol. Thus developers can be contributors and committers to code, participate in the governance, and help shape the protocol. This is the technology culture underlying the blockchain revolution.

By focusing on telecommunications services such as SMS, voice, video and related services, Restcomm Blockchain will integrate the latest innovations to power “Smart Business Communications Contracts” on a highly effective chain, designed for low latency, high throughput asynchronous transactions between globally distributed network of peers. Its utility token, Restcomm Token, is planned to be a “master token” to fund & empower new communications applications and projects, similar to how ETH is used for the current generation of Dapps and ICOs.

According to OpenHub - Restcomm (https://github.com/RestComm) is amongst the World’s most active Open Source projects with monthly contributors and commits metrics comparable to or exceeding popular Open Source projects such as Hadoop, Docker, MongoDB, Elasticsearch, Cassandra, WordPress and others. As of August 2018, OpenHub estimates Restcomm to have over 5 million lines of open source code built with effort of over 1,600 man years with estimated cost over $90MM USD.

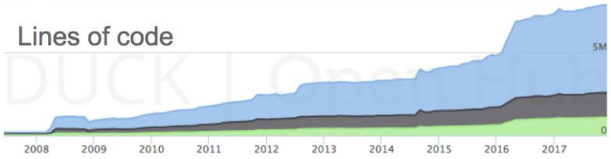
Among the World's Top Open Source Projects

Restcomm community of 10,000+ developers

*Statistics as of August 2018	Restcomm	ElasticSearch	MongoDB
All time commits	41,107	61,356	43,074
Years of developer effort	1,638	631	533
Code base in millions	5,5 million	2.1 million	1.8 million
Contributors last 12 months	114	276	150
Cost to create from scratch*	$90,035,843	$34,668,870	$29,287,965

*based on engineering salaries at 55K/yr

Source: OpenHub.net



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According to Forbes, Restcomm is revolutionizing the telecommunications industry with its progressive open source innovation model.

In July 2018, Restcomm was awarded the prestigious Innovator Award by Frost and Sullivan for Best CPaaS Enabling technology.

Blockchain technologies could provide natural solutions to common problems in a global b2b communications network. For example, the blockchain network's mechanism for reaching consensus amongst non-cooperative strangers (that is, reaching the Nash equilibrium of the network) is a key feature that could allow b2b sellers and buyers to reach agreements, and hence greatly reduce the cost associated with customer support and dispute resolutions.

The blockchain network's digital token could provide a very efficient in-network settlement currency, and greatly reduce transaction costs. It could also act as a springboard for members of the community to create their own initiatives, creating a strong network effect. The blockchain network's decentralized computing infrastructure could ensure that the marketplace will never go offline, and significantly reduce certain operator's IT expenses. Furthermore, blockchain technology could facilitate and even automate business transactions through the use of smart contracts and an immutable ledger.

2. Vision and Motivation

There are over 2 Trillion annual business calls and SMS worldwide at a retail price ranging from $0.01 USD to $0.25 USD per call minute and SMS. Due to inefficiencies in delivery and payment throughout the public telephone networks, as much as 60% of every dollar that an end customer spends for business communications services goes towards middleman fees. These fees cover “added value” services ranging from handling incompatible network interconnections to multi currency payment settlements.

Modern society’s communications infrastructure has evolved to favor the largest players, from legacy equipment retailers like Huawei and Ericsson to service provider giants like AT&T and T-Mobile. These players have accumulated the scale advantages that allowed them to achieve greater efficiency through centralized procurement, marketing, and distribution. But while efficient, these giants of telecom are completely centralized operations focused on selling few standardized products. The formula of selling a handful of cash cow products by acquiring smaller competitors, eliminating redundant operating costs and spending vast amounts on marketing and advertising to convince consumers and businesses to buy these products, has resulted in a stagnant environment where products are overpriced and there is little incentive or ability for creating value via innovation.

Recent Communication Platform as a Service (CPaaS) platforms have harnessed the power of the internet by enabling businesses to consume telecom services via REST APIs. They encourage the adoption of contextual communications across different categories and geographic markets. However, these platforms are also centrally managed, running all the functions such as voice termination, SMS termination, number registration, dispute resolution, payments, and allocation of telecom traffic. Often such telco service hubs (e.g. Syniverse, BICS, Twilio) implement an opaque policy, by hiding from buyers the original suppliers and their rates (e.g. hiding the name and rates of the voice termination partner for a given regional mobile number range).

As a result of centralizing all these functions and limiting payment solutions to a handful of reseller hubs (aka telco interconnect exchanges), the introduced middle-men fees can be as high as 60% of the original service provider rate, while quality may be reduced at the same time due to the additional latency and transaction processing at the hub. In the case when gray routes are allowed by hubs, and because the buyers do not have ability to trace the supply chain back to the source, the profit margin can be as much as 90% and coupled with subpar service quality, which is sometimes enabled by the borderline legal nature of such gray services (e.g. local SIM boxes) that subvert operator business contracts.

Furthermore, in pursuit of greater scalability on its centralized functions, many of the services sold by such hubbing platforms often come from larger, more established merchants, selling

products with larger profit. At the same time larger centralized merchants are able to pressure and marginalize original providers who do not have negotiating power. These original service providers are forced to settle for low rates in order to earn business, but in their own right seek ways to lower their costs to the point where it affects quality of service provided to the end customer. As a result the end customers expect to pay market rates for good quality, but the inefficiencies of the centralized b2b telco market provide lower than expected value for the money. This is akin to the well known economic "Market of Lemons" effect, where the quality of goods traded in a market can degrade in the presence of information asymmetry between buyers and sellers, leaving only "lemons" behind.

From its formation, Restcomm was set out as a very different kind of communication platform and marketplace, one that was built to enable truly open business communications. One that unlocks value from legacy communications assets as well as new OTT A2P channels (Apple Business Chat, WhatsApp, Android RCS, WeChat, Facebook Messenger, etc.) and incentivises skilled developers worldwide to build innovative communication apps that benefit businesses and consumers.

The core Restcomm team has nurtured the largest global Open Source Developer Community with tens of thousands of active developers and hundreds of contributors from all continents and all industries with passion for powerful intelligent communication apps. Developers from government regulatory organizations, Tier 1 telecoms, banks, healthcare organizations and universities have contributed to the evolution of the Restcomm Open Source platform.

Blockchain-based technology and decentralized processes can further revolutionize communications marketplaces and applications. We have seen that economic incentives, when transparent and properly implemented, motivate people to be active and good participants in a community. If those incentives can be earned throughout the various processes that run a marketplace and online community, then many marketplace functions that are currently centralized can be done in a decentralized manner, powered by the communities' own members. This strengthens the participation and creativity of its marketplace participants, while at the same time allowing the network to become even more dynamic and scalable.

While promising, existing blockchains have not been able to address the needs of b2b communications because 1) they are not designed to do so; 2) they have not solved the latency issues in order to support the high volume of transactions typical of a communications platforms; and 3) the current implementations of Smart Contracts are too low level and primitive for modern CPaaS use cases.

That is why Restcomm Blockchain will be a next-generation blockchain protocol with the following attributes:

- To support a large library of CPaaS-related Smart Business Contracts that power decentralization of processes

- To manage user identity & transaction data privately & safely, while enabling new transactions & settlements amongst network participants.
- To utilize a consensus engine to support tens to hundreds of thousands of transactions per second (“TPS”), hence resolving latency issues of existing blockchains.

In building this future, Restcomm has the potential to be the first blockchain with real-world business communications application and mainstream adoption, and may also soon be one of the largest blockchain networks in existence.

The Restcomm Blockchain Protocol and Token

Restcomm blockchain will be a new protocol specifically designed, developed and optimized for CPaaS and CPaaS marketplace applications. The protocol will consist of a blockchain based “virtual machine” and defined modules of a full telecom middleware stack, which operate outside the chain to support decentralized processes governed by smart contracts implemented on the network.

RCB (*a hypothetical name subject to change*) will be the native crypto token currency created to be integrated with and used on the Restcomm network, and on decentralized applications (DApps) on the network.

RCB will also eventually power the governance of the Restcomm Marketplace which would gradually evolve towards Decentralized Authority Organization (DAO) structure.

Initially, RCB is proposed to be issued and implemented on the public Ethereum blockchain as an ERC-20 compliant token. Restcomm will integrate its existing CPaaS “account billing” functions to hold RCB balances in the role of blockchain wallets, and allow users to utilize the tokens on the Restcomm platform shortly after the tokens are activated. The Restcomm protocol is being developed for implementation on its own open source blockchain.

In this scenario, the initial RCB based on ERC-20 would be exchanged on a 1:1 basis with native RCB issued on Restcomm’s blockchain, with any stored value & rights transferred to the native token.

Our aim is for RCB to serve the following purposes:
1. To reward and incentivize community members to contribute computing power and maintain the integrity of the network. Examples of such services could include running network nodes, validating transactions, and executing smart business contracts. When Restcomm market participants, such as wholesale connectivity sellers, app vendors and buyers, utilize the network services, they would provide RCBs to network maintainers.

2. To incentivize community members to provide value-added services, such as peer-to-peer customer support and conflict resolution services. The service provider could receive RCB from other members in the community after a consensus is reached.

3. To facilitate transactions within the network. Processes and interactions throughout the supply chain, as well as between buyers and sellers, could be recorded and facilitated by RCB. That allows for decentralized settlement and could potentially greatly reduce the cost of transactions and friction on the network. The network would extract a transaction fee to pay validators who execute smart business contracts associated with the transaction.

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5. To incentivize community members to provide peer reviews and ratings of apps and services offered on the marketplace.

6. To reward and incentivize developers to contribute new features, performance improvements, documentation, bug fixes, and other enhancements to the network software stack.

In order to create the Restcomm Blockchain, substantive research and development into blockchain technology itself is needed. This Open Request for Comments is intended to kick start a community discussion that will lead to a technical specification and open source implementation.

Why Open Source

1. Open Source is the best way to drive innovation and adoption that is resistant to special interests. There is no OFF switch as there is one for any commercial product or service. Everyone has a copy and can fork if the main branch doesn't work well or stagnates.
2. Telecom services for business communications are too important to fail. Unlike internet native services such as web and email, telecom services are still plagued by bottlenecks with single points of failure placed in outdated equipment that can cause hours and days of outages. Meanwhile voice and SMS are perceived as highly relied upon and even life critical (e.g. 911) for consumers and for business continuity. Telecom is at the level of financial and healthcare services uptime expectations. Modern Telecom protocols such as SIP allow for fault tolerance, but in reality there are many nodes in the global telecom network that deploy outdated or substandard equipment that does not follow best practices for robust, highly available and fault tolerant networks. This makes it

impossible for any communication service provider (CSP) to guarantee end to end quality of service when services involve end points outside their own network. Hence it is imperative that modern robust telco services implementations are ubiquitous and widely available to all participating nodes without compromise of quality.

3. Open Source accelerates consensus. Driving adoption and standardization via open source has proven successful across a number of technology infrastructure domains such as Operating Systems, databases, Internet, virtualization, mobile phone architecture, IoT and many others. Combining the open source meritocratic principles with blockchain democratic principles provides a winning formula for a successful positive-sum ecosystem.
4. Open Source drives commoditization. The telecom business continues to be plagued by legacy, non-standard, high priced telecom equipment. All public telecom networks aim to offer highest quality calls and messages between subscribers on their own and all other public telecom networks. To ensure quality and interoperability, telecoms spend tens of billions on third party testing services. Ironically almost all telecom products depend heavily on the same open source software stacks such as Restcomm. However they fork and heavily customize the code and quickly fall behind the improvements and innovation that goes into the original open source project. That leads to accumulating technical debt and growing gaps between proprietary vendor products. There is a historical misalignment of incentives between telecom operators and equipment vendors. An open source code base that is blockchain secured with incentives distributed reciprocally between all participants using transparent rules (smart contracts) can eliminate much of the inefficiencies with centralized proprietary equipment.
5. Uniform code base that serves all participating telecom operators can also automate disparte, inefficient processes residing in multiple legacy systems, tethered to proprietary appliances.

4. Potential Restcomm Applications

In this section, we discuss specific application scenarios and features that would be enabled by our proposed decentralized Restcomm blockchain solution, and contrast them with a typical centralized CPaaS marketplace. The Restcomm blockchain protocol has a built-in mechanism through its tokens to help non-cooperative network participants reach the Nash Equilibrium consensus.

Global communications network and marketplace that never go down

One of the key advantages of a decentralized network is the high availability of network services. It is resistant to data center failures. As long as some network nodes are running, the network services will be available – although the service capacity or bandwidth may fluctuate.

Today's CPaaS marketplace providers depend on centralized authority to approve server capacity. If the cloud service or a data center goes down, the CPaaS will cease to function unless the CPaaS provider's central authority approves the expense and allocates resources for the necessary failover capacity. There are a number of recent examples of such proprietary network wide outages.

Furthermore today's CPaaS providers offer Service Level Agreements that give their central authority the right to self-inspect and self-grade the availability and quality of their networks. In cases when their networks are down (according to their own measures), their recourse is to issue store credits to their customers, which are once again subject to their own central authority policy making.

In the Restcomm blockchain network, computing power and business services can all be provided by members of the community. And hence, the network service is more resilient to failures.

Fair Play and Fair Trade Principles

Today's big brand communications providers are often financially leveraged and support expensive sales and marketing organizations that create a perception in the market for superior product.

This leaves local providers of communications services in the shadow of large brand marketing campaigns and artificially blinds users to lean towards shiny objects instead of the healthiest product choice for their business.

The large marketing and sales financed campaigns approach works for a small set of companies and creates a winner takes all environment that tends to converge towards oligopoly if not monopoly in certain geographies and demographics. Monopolies are subject to antitrust laws, but history shows that its a long road to prove and break up a modern company with monopolistic tendencies.

As large companies scale, they naturally look for ways to recuperate expenses that fuel their growth. Often times that leads to sourcing their storefronts with products that come at the lowest possible cost and sell for the highest possible price that the market will bear. Such pricing aims to maximize profit margins for the big brands, but does little to benefit original providers at the source.

Hence its in the best interest of the communications ecosystem to create a future proof network that is by definition, design and with mathematical assurance with decentralized authority and does not require concentration of trust to operate effectively and fairly.

Farm to Table: A more efficient supply chain

In a telecommunications ecosystem, the seller needs to procure products from suppliers and then deliver to buyers. In the process, the product (call route, SMS route, DID) goes through multiple resellers or agents. In a traditional system, the transactions along the supply chain must be settled using fiat currencies, which create significant friction and cost.

However, in a token-based system, transactions amongst community members may be recorded instantly and securely using digital tokens. The parties would only convert any excess tokens into other assets from time to time on an “as needs basis”, limiting transaction costs.

Rewarding Open Source code contributors

The recent $7B acquisition of Github by Microsoft put to rest any doubts that there is a tremendous value in open source software that will continue to grow.

Restcomm marks the first stage in a new wave of open source communities that enable all contributors and users alike to take part in the future success of the ecosystem.

In the current Open Source Community, there are two main operating models:

1. Key contributors publish their code under an OSI approved license that allows anyone to benefit from it without rewarding in any way the contributors. Contributors participate in the project for fun or some transient incentive such as university research paper, competition reward or employer assignment.
2. Contributors publish a basic version of the software under open source license and separately build a more robust commercially viable version.

In the first model, users of the code cannot expect any level of commercial grade code quality or support. They can fork the code, fix bugs on their own and self support when issues come up. By forking the code, they reduce the long term value of the original codebase. Unless they chose to nurture an open source community around the fork, it becomes a dead end private branch.

Users can alternatively try to negotiate contracts with key open source contributors to help with bug fixes and enhancements. If agreement is reached, the user normally pays the key contributors for the work. The implemented improvements benefit the open source community and the users who paid for the work.

In the first model, contributors are normally driven by short term incentives and aren’t readily available to work on improvements.

In the second model, contributors have conflicting interests between open source code and commercial code. If the open source code is low quality, it won't attract a vibrant community. If the open source code is of high quality, there will be little incentive for users to pay for a commercial version of the code. However without sales generated by a commercial version, contributors have no monetary incentive to continuously improve the open source code.

With the Restcomm blockchain network, we can design incentives for contributors to write high quality code and attract other contributors from around the world to accelerate the Restcomm project roadmap and further network adoption. For example contributors can run Restcomm nodes themselves and receive rewards from users of the network who submit transactions to the blockchain.

Another way for contributors to receive incentives is via smart contracts on the blockchain that solicit open bidding for new features and bug fixes. For example contributors can publish new feature proposals on the public project roadmap and start an open bid for 30 days with a minimal RCB amount required to begin the work and finish within a given period of time. Participants of the network can commit the amount of RCB they are willing to pay towards the proposal.

When sufficient amount of RCB has been committed that meets the minimum requirement, the smart contract can ensure that the contributor receives the requested RCB if the work is completed in the given time period. If the work is not completed to the satisfaction of any of the users, they can trigger a dispute which is resolved by arbiters on the network via the aforementioned example procedure.

In case the proposal does not raise the requested RCB funds, the contract automatically releases the committed funds back to the users.

Network users can also initiate new feature proposal bids. They can propose a feature and commit to pay a given RCB amount towards the implementation total cost. Contributors and other users can review and choose to participate in such proposals.

The novel and exciting part about this incentive mechanism that has not been available before comes after the implementation and release to the network of a new feature or a bug fix. Its true value to the Restcomm ecosystem will be reflected by the level of usage that follows its implementation and deployment to the network. If its a high value feature or a critical bug fix that makes the network safer or more efficient the results will follow. It will manifest in higher transaction rates among nodes, new types of transactions or both. Either way the increased utility will heighten demand for RCB in circulation, which will drive their value up.

The reward to a contributor resulting from their code enhancement may grow exponentially as it becomes adopted across the network. If a contributor believes their code will have tremendous

boost to the network, they will keep their RCB reward and seek to earn more in order to benefit from its future appreciation.

This proposed model also incentivizes contributors to attract more code contributors. As new contributors add value to the network, existing contributors will benefit further from the appreciation of their RCB holdings.

A key property of this open source development incentives model is that its transparent and rewards are distributed fairly via decentralized public governance. It is not "the powers that be" in an ivory tower who make decisions about hiring, issuing equity or cash rewards to retain the best contributors. The network community can implement rewards based on merits.

Democratic community management

In a b2b marketplace, the most contentious problems are related to centralized management. For example:

- Account closure. In a centralized marketplace, the marketplace operator can unilaterally close accounts. That could negatively impact the affected sellers and buyers, as it takes significant time and monetary investment to build up highly-rated accounts.

- Censorship. The marketplace operator sometimes needs to intervene and remove illegal products offered for sale (e.g., grey routes and numbers in certain countries or regions). In a centralized marketplace, the operator makes unilateral decisions. Such decisions are expensive (as they often require legal expertise and review), create large potential liabilities, and can even cause resentments in the community if users believe they have been improperly made.

We strongly support safe and appropriate marketplaces. However, centralization by its nature concentrates decision-making into a single person or body.

RCB and the Restcomm blockchain platform, through smart business contracts, could provide ways for the community to manage and regulate itself. We can introduce a voting mechanism that is similar to the “Proof-of-Stake” (“PoS”) consensus process. This would require the community to come together and reach consensus on issues related to the management of the whole network. Such consensus could be reached through the use of smart business contracts. To illustrate a potential scenario:

- A person in the community brings up a request to close an account or censor an app listing for any reason. This person pledges a specified number of RCB in a smart business contract when making this request.
- The network automatically requests a number of (for example, 100) random token holders to vote on this issue. Each vote costs a certain amount of RCB depending on the

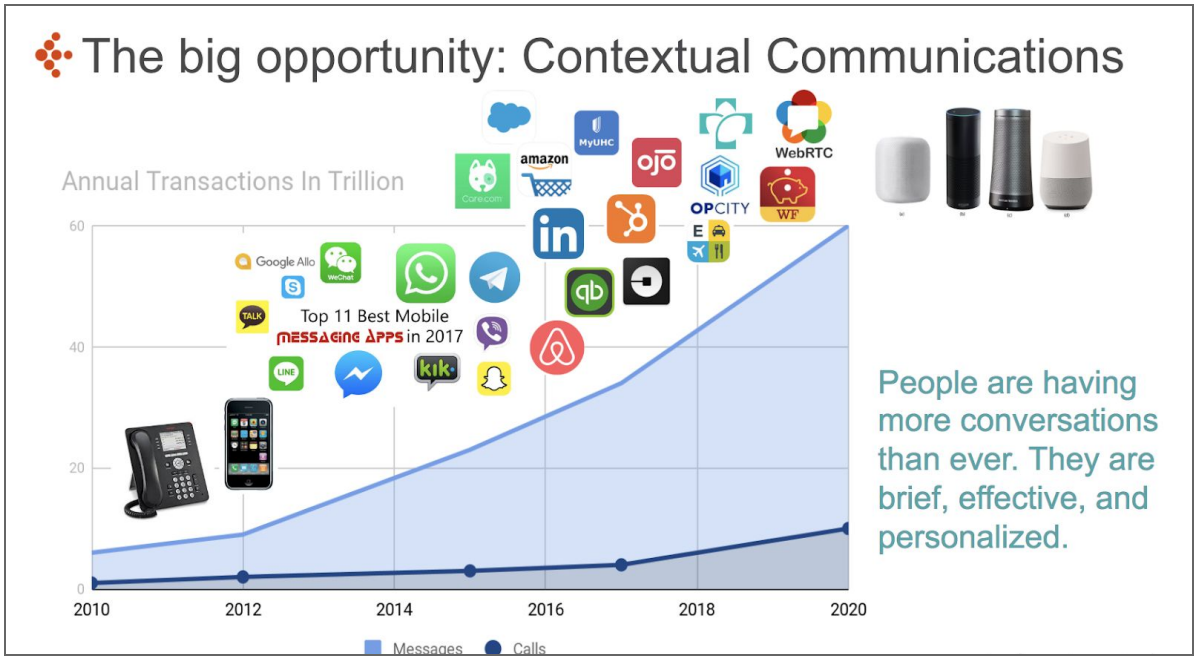
system setup. The voting results are binary, and a simple majority determines the outcome.

- Depending on the voting result, the initial requester wins or loses the case. And everyone who casts a vote either prevails or forfeits (that is, according to whether they voted with or against the majority decision).
- The pledged RCB from the initial requester and the payment from each voter is put into a collection of RCB held by a smart business contract.
- Depending on the outcome, the initial requester could forfeit their pledged RCB (if the request is voted down), or get back the pledged amount plus an allocation from the RCB used to cast a vote (if voted in his/her favor). The majority voters get back their contribution, plus an allocation from the other RCB used to cast votes. The other voters receive nothing.

A system like this creates incentives for community members to participate in the management of the network itself. It could be far more effective and cheaper than a centralized system.

Decentralized Omni-channel communications APIs

Business voice and messaging have been growing exponentially for years and there is no sign of slowing down. Consumers love communicating in natural language and they are happy to break the shackles of point and click GUI that has restricted interaction with intelligent applications for over 40 years since the 1970s introduction of mouse and menus.

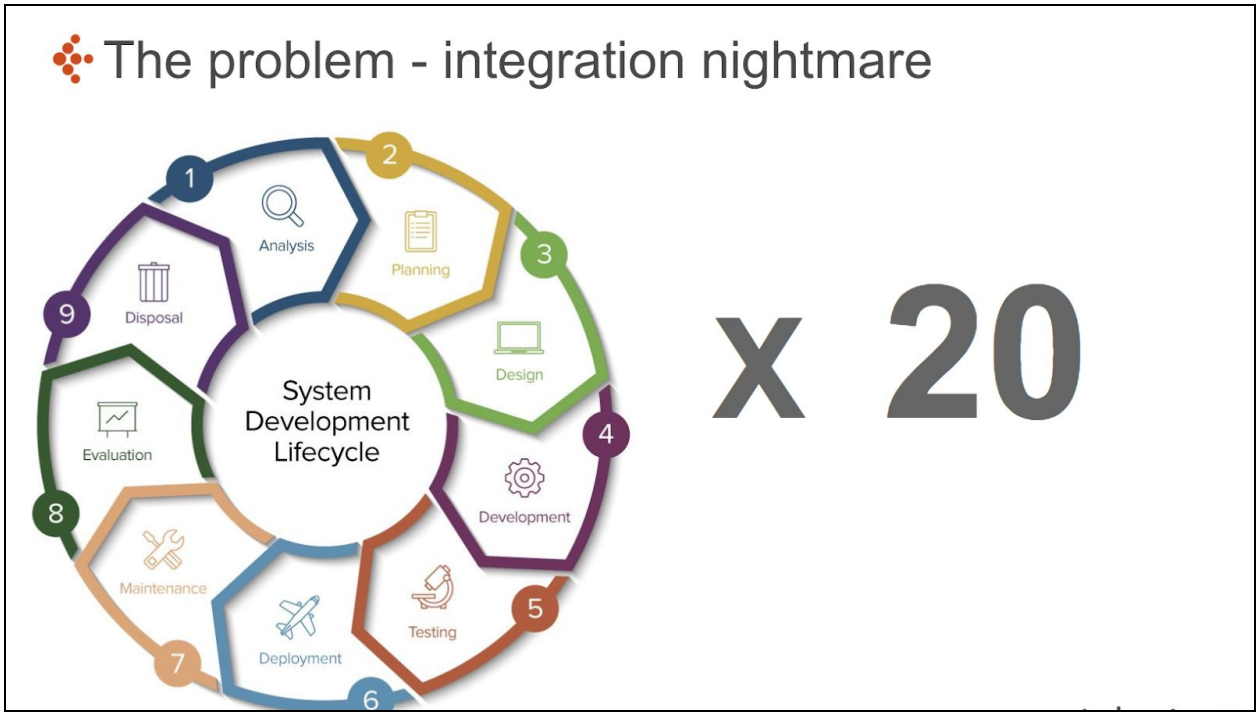


In recent months, business rich messaging, voice and video APIs have exploded across a number of major consumer communication platforms such as Apple iMessage/ Business Chat, Android RCS, Facebook Messenger, WhatsApp, Viber, Line and others.

With consumers quickly adopting natural communication interfaces across a number of channels with concentrations by geography and demographics, businesses are wise to follow the money by engaging their target audience via the preferred communication channels.

Each communication platform provider has its own unique rules and processes for accepting new businesses to communicate with its users. Each provider has its own set of unique APIs for A2P messaging and calls.

In order for a business to engage with its target users via the user's preferred communication platform, the business has to apply for an account, design, build, test and keep up with each provider policies and API changes. This can be a prohibitively expensive approach for all but the largest brands with infinite development resources.



A number of CPaaS vendors have recognized this inefficiency and have announced their support for multiple messaging platforms from SMS to OTT flavors. Such hubbing solutions have began addressing the problem of writing redundant application messaging code to multiple similar but different APIs by introducing a gateway API.

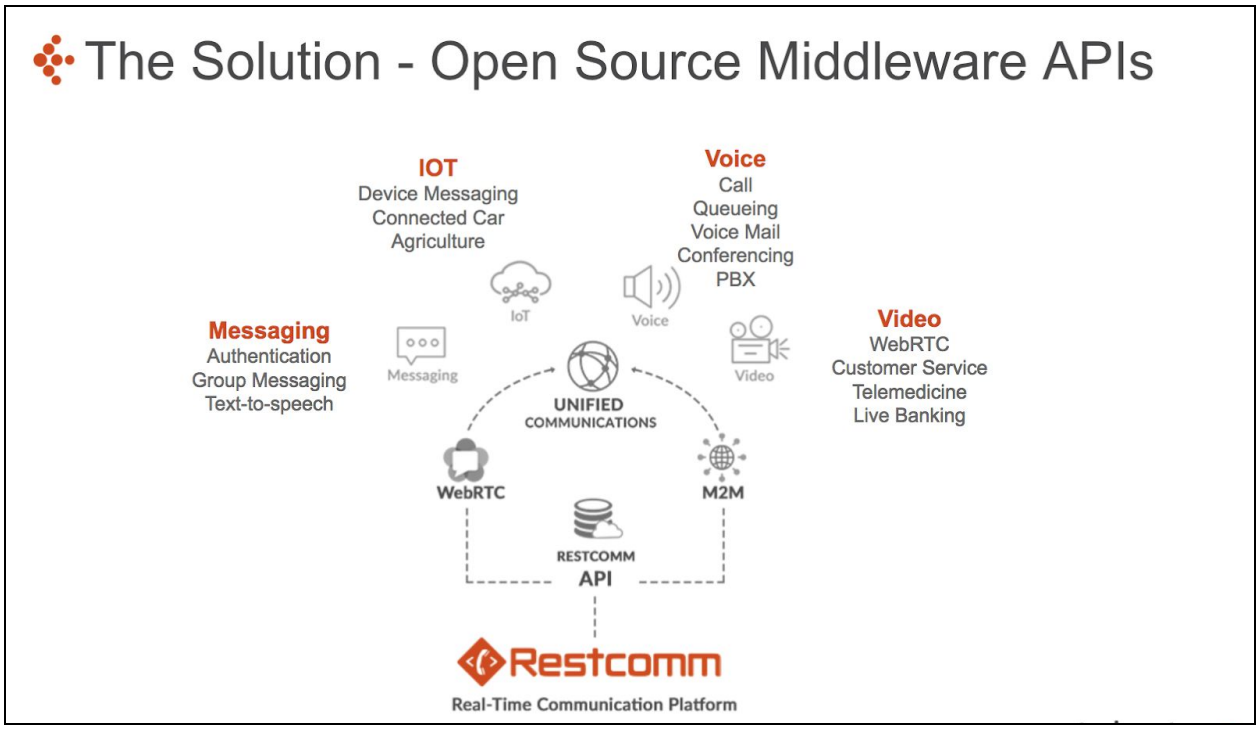
However these proprietary gateway APIs have not addressed the problem of managing business identity for each platform. Businesses still have to apply and obtain an API key (or a similar secure identity token) for each communication provider before they can use the gateway API.

Furthermore, each CPaaS provider has a different proprietary roadmap with its own board managed priorities for implementation and maintenance of omni-channel architecture. As a result each commercial CPaaS vendors has a different level of support for Tier 1 communication platforms ranging from preview to closed beta to invitation only and eventually pubic.

The lack of roadmap transparency leaves application developers wondering which gateway API to chose. They can place a bet on one, code to multiple gateway APIs or just go back to the original problem of coding to one or more direct Tier 1 APIs.

With Restcomm blockchain we will address simultaneously three major problems of omni-channel business communications:

- Multi-vendor messaging and call API gateway with decentralized governance of roadmap and implementation.
- Decentralized multi-vendor business identify management that is acceptable to Tier 1 providers. Identity management solutions are described in more detail in the following sections of this paper.
- Moving value towards the edges and away from middle-men by enabling anyone to run the full Restcomm Open Source stack or a subset of it on the blockchain network.



A decentralized business identity management platform

Recent history records a long list of examples where traditional telecommunications platforms are insufficiently protected against identity theft. Many participants in the telecom ecosystem have been victim to malicious attackers who impersonate the identity of a legitimate network peer and run traffic for days and weeks that adds up to liability in the tens and hundreds of thousands of dollars. Some of these attacks have put a companies out of business.

To solve this problem, one must rethink the whole paradigm of telecom business identity management, whitelisting and peering procedures. The sellers should be able to decide, on a case by case basis, who has access to their network. The access timing, duration, and accepted use of the network should all be approved by the seller.

Blockchain networks manage identities through cryptographic keys. The user's "wallets" on bitcoin or Ethereum blockchains are decentralized, and entirely controlled by the user through her private key. Using Smart Business Contracts, we can extend the concept of "wallets" to include a secure deposit of not only crypto tokens, but also arbitrary identity information. Like cryptocurrency wallets, there could be many "personal identity wallets" on the network.

For example we can implement a scenario where a buyer and a seller agree to exchange network peering information and this agreement is recorded as a transaction on the blockchain. A buyer can initiate a peering interconnection request. The seller will receive the request and approve (via transaction signed by the seller's private key) the request. Their wallet can authorize a buyer designated application to access the seller network peering information temporarily via the OAUTH protocol.

This particular "wallet" stores the seller's network peering information. Hence the seller can authorize buyers on the Restcomm network to utilize it.
1. The seller selects a "wallet" app she trusts.
2. The seller registers peering information with wallet.
3. The wallet does AML / KYC validations for government mandated anti-money laundry check.
4. The wallet generates a public / private key pair and then broadcasts the public key to the blockchain for record.
5. The wallet authorizes and tests the peering information.

Peer-to-peer business credit agreements

A potential application built on the Restcomm blockchain would be a peer-to-peer loan marketplace. As described in the previous section, we will build a decentralized identity management platform on Restcomm. The blockchain can then record the credit history for each user identified by her public key.

With a publicly verifiable credit history in place, we can then implement seller contracts that automatically extend credit to buyers that are creditworthy. For example a buyer with strong credit record can be allowed to upgrade from a 7+3 contract, where the buyer gets their bill once a week and they have to pay in full within 3 days to a 15+15 contract which gives more leeway for two weeks usage term followed by payment within 2 weeks.

Once loan terms are matched, the Smart Business Contracts would automatically settle the loan directly from the buyer's account using RCB (authorized via their "personal information wallets") without a central clearing house. The transaction result is broadcasted to the blockchain, and become part of the credit history.

As the network scales and the cumulative number of credit contracts between peer nodes grows, further efficiencies can be introduced. Using directed graph arithmetics similar to the

ones employed by the Ripple IOU token, credit contracts can cancel out automatically and settlement transactions between peers can be reduced.

Decentralized Rate Exchange

Telecom services rates change regularly based on a number of factors: local taxes, currency exchange rates, pricing policy changes, QoS upgrades, capacity upgrades and other factors. The currently accepted mechanism for rate updates between communication network partners is via email, seller web page update or CSV upload to an exchange portal. Each of these require manual steps, causes delays in the order of days and weeks between intention and implementation. It also requires high level of trust between each pair of partners in the network. A human error in the placement of a decimal point position could cause large payment liabilities and lead to undesired dispute situations. An example of such dispute between Rogers Communications and Bell Aliant was published in the New York Times.

We can implement Smart Contracts for rate updates which will regulate the process in a decentralized automated manner. The smart contracts can control variance in exchange rates, update frequency and other common rating terms. Such contracts would be signed by partners (with their private keys on the blockchain). Consequently, sellers will trigger smart contracts to store immutable records of their rate updates in the blockchain, with an effective date linked to a uniform network wide accepted timestamp (e.g. the transaction block timestamp).

Decentralized Number Portability

Local number portability (LNP) for fixed lines, and full mobile number portability (FMNP) for mobile phone lines, refers to the ability of a "customer of record" of an existing fixed-line or mobile telephone number assigned by a local exchange carrier (LEC) to reassign the number to another carrier ("Service Provider Portability"), move it to another location ("Geographic Portability"), or change the type of service ("Service Portability"). In most cases, there are limitations to transferability with regards to geography, service area coverage, and technology. Location Portability and Service Portability are not consistently defined or deployed in the telecommunication industry.

In the United States and Canada, mobile number portability is referred to as WNP or WLNP (Wireless LNP). In the rest of the world it is referred to as mobile number portability (MNP). Wireless Number Portability is available in some parts of Africa, Asia, Australia, Latin America and most European countries including Britain; however, this relates to transferability between mobile phone lines only.

Number portability has been gradually accepted and even mandated in most countries across wireline and wireless operators. Number portability gives control to consumers and business users to choose the best provider for their communication service needs.

In practice number portability has not been standardized uniformly across operators and countries. Porting and routing procedures vary from country to country and require technical as well as legal understanding of the currently active policies by country and operator. For example in the US the FCC regulates portability via NPAC (National Portability Administration Center).

It can take days and in some cases weeks for a number to be ported from one service provider to another. The donating provider has little incentive to “give up” the number other than fear of the law. The donating provider also has no clear incentive to implement routing of call or message requests to the receiving provider which is also their competitor in the market.

We can implement Smart Contracts that automate number porting procedures. End users can sign port request transactions along with the receiving provider, which will be documented in the decentralized ledger and automatically trigger related transactions that publish the new routing information for the ported number. That will eliminate the inefficiencies and centralized security issues caused by conflicting interests between the donating provider and the receiving provider.

Decentralized Equipment Identity Register (EIR)

A Central Equipment Identity Register is a database of the IMEI numbers of blacklisted handsets. If a device's ESN or IMEI number is listed on a CEIR, it is not supposed to work on member service providers' networks; only paying members may access the database.

A common usage of a CEIR is with stolen mobile devices. Once a user reports to their operator about the theft, the mobile device's IMEI number should be entered into the CEIR, supposedly making the device unusable in any network (although this does not always work).

A key reason this sometimes does not work, is that while many operators from many countries contribute IMEIs to the CEIR, each also having a unique profile that determines which operators' blocks will be included on the CEIR updates received by each operator. The UK networks for example, do not receive those block records originated by non-UK networks. Annual fees are required for access to the CEIR, and access is tightly regulated.Contributing operators decide for themselves which handsets they will block from their own networks, and many network operators simply do not participate at all.

Currently, the Central Equipment Identity Register is more frequently called an IMEI DB (database) system which means that it is a central system for network operators (those that have an EIR) to share their individual blacklists with one another so that service is denied for the particular devices that appear on that blacklist. The idea is for network operators to compile one global blacklist through the IMEI DB. However, there is no agreement on a single CEIR.

We can implement a decentralized EIR that enables operators globally to participate, share costs and benefits. We can link the EIR service to RCB incentives by rewarding proportionally

operators running full Restcomm blockchain nodes for their effort to validate and store the full database. Smaller operators and aggregators can run only light client nodes that store and validate only blockchain transactions with information linked to their own assets.

Decentralized Caller ID Name Directory

When phone calls are made, there are usually two user-facing identifiable pieces of information: a phone number and a Caller ID Name (usually a 15-character string). CNAM (Caller ID Name) can be used to display the calling party's name alongside the phone number, to help users easily identify a caller.

There are numerous CNAM lookup services which offer CNAM lookup by specified phone number for a small fee. The telephone Caller ID Name information is stored by the telecom operator responsible to provide service for a given phone number. In order to lookup the CNAM by phone, the lookup service has to be interconnected with all operators or with aggregating CNAM services that are in turn interconnected to operators.

There are a number of inefficiencies in the current naming system. Operators have the responsibility and liability to provide accurate information. Integration interfaces are not uniformly standardized and there are various intermediaries who cache information and may not reflect the most recent changes in the operator database. There is also no uniform protocol for propagating changes throughout the naming network services.

We can implement a decentralized and secure naming service on the Restcomm blockchain which allows uniform protocol for updates and lookup across all participating operators. The Ethereum Name Service and the earlier Namecoin blockchain provide robust frameworks for a decentralized modern caller ID name directory.

Secure Roaming Disintermediation

For many years roaming charges have been a significant portion of mobile operators' revenue stream. Mobile subscribers used to be charged as much as 10x (ten times!) for voice, SMS and data usage when travelling abroad as compared to their home country charges. While the cost to the home and visited operators have been only marginally higher as compared to in-country usage. This drove subscribers to consume 300x (three hundred) times less services while traveling as compared to

In 2017 the European Commission enacted new "roam like at home" rules that capped roaming charges and moved all mobile operators in the EU market towards a single uniform rate plan from a subscriber's perspective. Under the new rules, when a subscriber uses her mobile phone while travelling outside her home country in any EU country she doesn't have to pay any additional roaming charges. She can benefit from these rules when calling (to mobile and fixed phones), sending text messages (SMS) and using data services while abroad. These rules also

apply when receiving calls or texts while roaming even if the person you are calling is using a different service provider.

Following the EC decision, some mobile operators began launching “rome like at home” plans that extended beyond Europe. Alternative Roaming Providers also appeared on the market with solutions based on multi-IMSI technology that allow a single SIM/eSIM to switch to a local operator contract automatically when the subscriber moves across borders. Over-the-top data only alternative operators also entered the market.

By design and in effect, consumer and business mobile subscribers are the main beneficiaries of the regulatory led disruption of the roaming market. The cost for mobile subscribers to use mobile voice, SMS and data services at home and internationally will continue to drop. However it's still an open question how mobile operators will be motivated to offer new and better services at high quality as consumer prices continue to drop.

One solution is to disintermediate roaming infrastructure in a secure and cost effective way - from core network service interconnects to billing. We will implement a hybrid blockchains with permissioned and public components to facilitate the implementation of databases that usually require costly integrations and trusted access settings. An open source blockchain secured roaming middleware will log roaming transactions in an auditable, distributed and immutable ledger. It will also validate and verify subscriber identities. Smart contracts will automatically trigger account settlement in RCB based on transaction volumes and payment terms between partners.

By removing overhead from existing roaming Clearing Houses and Settlement, mobile network businesses can free up resources to focus on value creation and innovation in the CPaaS market.

While person to person (p2p) mobile services including roaming are going towards zero cost, the value creation in the business to business and business to consumer mobile communication services is just starting to flourish. Lead by new generation CPaaS providers such as Twilio, Nexmo, and MessageBird and disruptive unicorns such as Uber and AirBnb, the value of Application to Person A2P communications use cases is validated and multiplying fast across industries and geographies. Therein lies the key to a transformative opportunity for companies with mobile network assets and expertise.

Telephone Number Feature Registry

Traditionally phone numbers were only landline and supported only voice calls. Over time fax service became available on some phone numbers. When mobile phones came in service, SMS also became available as a new feature for mobile phones. In the past few years, in the US and some other countries, SMS is becoming gradually available on landline phones.

The trend is to move phone numbers to virtual addressable end points with a variety of features accessible on one or multiple devices. Innovative communication service providers are introducing APIs for provisioning phone numbers and programmatically implementing workflows for voice, SMS, MMS, fax and other communication features. New contextual communication applications are expanding the use cases where telephony can be used for better user engagement.

Modern communication apps may entirely handle the call or messaging logic or they may handle part of it and hand over at a certain point to a human agent at a device that the agent is available on - desk phone, computer, tablet or mobile device.

It is often helpful to know in advance what features a phone number can support. For example if a phone number only provides voice service, the application or operator on the calling side will not attempt to send SMS. However if SMS is available, it can be used to send information after a voice call or it can be used entirely for an asynchronous conversation with the end user if that is their preference.

New telephony services are being introduced over the Internet Protocol, independent of the legacy telecom protocols. For example RCS is advancing as the next generation rich messaging service over IP. RCS is being adopted across Android devices but its an open standard that may be implemented by any mobile device or virtual application in the future. Other IP communication services that gained popularity among substantial subscriber bases for person to person communication and are expanding into business to person communication include Facebook Messenger, Apple iMessage, WhatsApp, Line , Viber, and others.

We can implement a decentralized registry on the Restcomm blockchain where service providers can publish capabilities attached to phone numbers with the permission of the subscribers who currently own the service for a given number. That will allow applications to lookup the full set of features that a phone number supports and use the most effective one for a particular use case.

Note that in the proposed directory the subscriber identity need not be revealed. Only the phone number and available features can be listed. Application providers would still need to comply with all applicable privacy policies such as GDRP to obtain subscriber permission to contact them on the phone number via any of the available features.

Communications App revenue sharing

Value Added Services (VAS) is a large growth opportunity for telecoms and solution providers. However in the current market, there is often a prohibitively high cost for a new VAS entrant to introduce an innovative solution due to the commercial, technical and political complexities of integration into a legacy carrier network.

Tier 1 operators keep as much as 90% of a Value Added Service revenue on their networks and on top of that push much of the development and implementation risk to the VAS provider There is also the artificial red tape placed by incumbent NEP vendors that run the operator's core network services which a new VAS provider has to integrate with. Incumbent NEP vendors prefer to block competition from new VAS entrants and implement their own version of the same solution leveraging their incumbent position.

The issues listed above have lead to a stagnant VAS market that slows down innovation. As a result a new generation of Over The Top (OTT) marketplaces for communication apps have been gaining ground in recent years, bypassing the need to integrate with telecoms. Examples include Google Play, Apple App Store, Facebook Messenger, WhatsApp, WeChat, iMessage.

Telecom service providers have been aware of these issues and have attempted to regain control of their destiny by moving to open source and virtualized software driven infrastructure, away from big iron black boxes.

The Restcomm Marketplace can be a major catalyst of this process of liberating operators to innovate by introducing a decentralized network infrastructure and app marketplace where efficiencies are driven by standardized implementation and incentivize all network participants to add value. Malicious players can be booted out of the network if they do not agree with the majority of the network participants.

Service providers won't have to decide upfront on the revenue share fee. They can let the network choose an optimal equilibrium of pricing and revenue share contracts that create maximum new value for the ecosystem. Since service providers participating in the Restcomm network are RCB holders, the increased value of the ecosystem will result in appreciated value for their RCB holdings.

For example one type of smart contract that application developers could publish would offer discount or revenue share incentive to service providers to promote the new app to their subscribers. Based on these contracts, service providers will automatically receive their RCB rewards for each application originated or application terminated transaction.

Addressing grey routes and fraud

Grey routes, SIM farms, traffic pumping and other fraud are serious problems in telecom marketplaces. It is estimated that the fraud costs Service Providers USD 40 billion each year. For a centralized operator to address this problem, it must generally review and track every product originating from a third party and offered to their customers. That is prohibitively expensive for most telecom operators, and ineffective as it takes substantial legal and technical reviews with multiple parties and human resources. It is practically impossible for all but a few very big operators to evaluate the authenticity of all possible telco products in a marketplace, even with the assistance of testing technology that is currently available.

As a result, most centralized marketplaces can only reactively deal with counterfeit products, creating a “cat and mouse” problem that is common to all centralized systems. A blockchain-based network can help resolve this problem much more elegantly.

- Proactively: One of the key features of the blockchain is the immutability of its records. That makes it ideal for tracking the authenticity of applications and services. Sellers can create certificates of authenticity for applications. Once the certificate is associated with recordable features of an application or service, and relevant information is stored in a distributed ledger, its ownership can be tracked and the risk of tampering is significantly reduced. That allows buyers (or even arbiters) to review the entire history of the app in the system, depending on the information recorded and visible.

- Reactively: As we discussed earlier in this white paper, the Restcomm blockchain network provides a mechanism for community-based conflict resolution. That of course includes the cases where the buyer disagrees on the authenticity of the product. In disputes alleging fraud, the buyer would need to provide evidence in support of its claim in order to obtain a favorable decision from the arbiter.

The Restcomm community can be incentivized to come together and prevent malicious apps and service frauds on the network.

Future Research and Development

The intersection of telecommunications and blockchain technology presents a tremendous opportunity for research and innovation. This paper captures initial ideas and proposes a potential path to execution. Its an exciting topic that will evolve very quickly.

Hereby I extend an open request to the wide community of technical and business experts with entrepreneurial spirit and passion for innovation to take part in this imminent wave of disruption. Please feel free to share your feedback as public comments or if you prefer via private communication. Looking forward to a constructive open discussion.