Open Source and Standards
The Role of Open Source in the Dialogue between Research and Standardization

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Abstract—Open Source communities have emerged as increasingly popular structure for the rapid introduction of software standards. The Telecom industry is increasingly based on deployment and operation of software technologies for infrastructure services, not just enterprise support functions. As Open Source communities are increasingly enabling new innovation ecosystems for communications services, they are expected to take on a key role in the process of developing Telecom industry standards. This fundamental transition is being driven by a technology evolution that will raise organizational, legal, and architectural challenges to the Telecommunications industry. While the challenges have to be carefully considered, the business agility and operational efficiency potential of Open Source adoption is expected to mitigate the difficulty of adopting this new model for designing, developing, testing and deploying network solutions.

Keywords—Open Source Community, devops, continuous integration, standards, Industry Alliance, business agility, innovation, collaboration

I. PURPOSE OF STANDARDS

Standards are strategic tools that enable companies to increase productivity, reduce waste, access new markets, participate in free and fair global trade; and trace back at least to the ancient Egyptians [1]. Interoperability reduces transaction costs associated with interconnecting systems and creates other economic benefits: network externalities, competitive effects, increased variety of goods and services enabled by underlying interoperability, economies of scale [2]. Standards can be considered as de jure -enforceable by authority (e.g. through regulations) or de facto – enforced only by custom and consent in the course of trade. For de facto standards, success lies in the scale and rapidity of adoption.

Standards exist in a variety of forms, but are often embodied as specifications. Specifications enable, but are insufficient to guarantee, interoperability [3]. Standards can also provide a pattern or guide to facilitate other commercial activities. Physical reference models have been used as the international standard for mass. Implementation of some specifications may be required before they can be considered as having the status of standards [4]. Reference implementations (e.g., of APIs) can facilitate adoption of the technology by providing both a design pattern and a gauge to test other implementations against (e.g., by compilation).

Standardization and innovation are increasingly coupled [5]. Innovation can occur through technology research and also through development of products and services. The fundamental purpose of research is the accumulation and dissemination of new knowledge; commercial entities create economic value through the delivery of products and services. Interfaces enable new markets for the more complex products and services enabled by standardized interconnection, though the economic outcomes may not be easily predictable [6]. The dialogue between standardization and research activities enables research advances to be disseminated into industry, but also provides an opportunity for industry to identify use cases and issues where further research may be economically fruitful. Like accumulation and dissemination of knowledge, industrial standards can be considered a public good [7], though unimplemented specifications are economic waste.

Section II describes the role of Industry Alliances developing telecom standards. Section III explores Open Source communities as Industry Alliances. The rise of Open Source Industry Alliances in the Telecom industry is considered in Section IV. Conclusions and recommendations are offered in Section V.

II. ROLE OF INDUSTRY ALLIANCES DEVELOPING TELECOM STANDARDS

A. Industry Alliances for Market Driven Standards

The US Standards Strategy is open and inclusive, market driven, sector based, consumer focused and globally relevant [8]. Standards are catalysts in developing technology

References

[1] See e.g., http://www.iso.org/iso/home.html

platforms supporting ecosystems of users, manufacturers, service providers and regulators. In the Telecom industry, regulated services created the need for international standards to support interoperability between the networks connecting users across the world. With the deregulation of the Telecom industry, various consortia have arisen for negotiating and advocating the commercial adoption of de facto standards [9]. Industry Alliances for negotiating and advocating standards are typically non-profit joint ventures (Trade Associations, Standards Developing Organizations (SDOs), Standards Setting Organizations (SSOs), etc.) enabling new industry technology platforms [10]. Industry standards enable external, industry technology platforms and ecosystem innovation with different characteristics than technology platforms that are internal to the firm [11]. Cooperative and competitive business challenges driving standards change with the market ecosystem lifecycle [12]. Commercial entities participate in standardization because they expect to benefit from revealing, and advocating, their innovations [13]. Commercial entities benefit from both the standards (developed by Industry Alliances) and from the process of developing that standard [14]. Commercial entities derive greater process benefits from participation in the development of standards when they are more technically capable, value the forthcoming standards more highly, and participate in better-managed consortia [6].

Industries can be considered to have a life cycle where the focus of competition and innovation evolves from products to processes and then to services, unless interrupted by some other technological discontinuity [15]. Traditional value chain analysis focuses on the value creation within the firm as part of a supply chain. Deregulation of the Telecom industry places increasing value on meeting the evolving needs of the consumer rather than static regulatory service requirements. Business models have evolved from selling software to providing services, e.g. where software itself is not the revenue generator but the enabler to connect to cloud services. Publishing the source code can lead to increased ecosystem adoption. Proprietary de facto compatibility standards trade off control of the standard against wider adoption [16].

The only truly sustainable competitive advantage for most companies comes from out-innovating the competition [6]. This pressures competitors to develop and deploy their products and services faster. Even a perception of shorter lifecycles for products and services [17] can impact behavior of market participants. Specifications that are developed too late represent an economic waste of resources. Viable market ecosystems have multiple participants with different roles in the ecosystem. These market participants co-evolve with the market in response to changes in market conditions as well as technology trends. The individual firm in competitive markets has to respond incrementally to continuous change with continuous change [18]. Roadmaps may provide useful perspectives on the evolution of technology platforms, both internally within the firm and across market ecosystems [19]. These market dynamics require the standards associated with the technology platform underlying the market ecosystem to evolve as well. This need for evolution in standards places emphasis on component standards that are easier to evolve independently rather than system standards [20]. The Telecom infrastructure is a large scale distributed system and this commercial requirement for continuous evolution, including the ability to add, remove or replace elements argues for extensible, loosely-coupled system architecture [21].

B. The Nature of the Work of the Industry Alliance

Participants of Industry Alliances negotiate amongst themselves the details of interface standards and advocate adoption within the marketplace. Industry Alliances may use, extend or profile the work of other Industry Alliances to suit the needs of their application. Beyond promulgating their own agreements, they may request changes in the referenced specifications developed by the upstream organizations. Industry Alliances may accept requests for changes in their specifications where they believe this leads to technical improvements, increased adoption, or removes errors. While Industry Alliances strive to avoid duplication of effort, they may also fork the development of their specifications into multiple streams to create specialized variants or implementation options targeted for particular niches. The specifications and other artifacts developed by Industry Alliances depend on market adoption for success, and may be seen as competitive if the targeted niches are not independent.

The act of source code publication does not create an industry standard. It is the testing, deployment and market adoption that result in the recognition of an API or implementation as being the relevant standard. Industry Alliances have a role in facilitating multi-party interoperability activities to demonstrate the viability of Open Source solutions in a variety of different contexts. The individual actions of commercial entities in selection and adoption are what distinguishes a market driven standard.

III. OPEN SOURCE COMMUNITIES AS INDUSTRY ALLIANCES

A. Open Source communities

Open Source implies more than published code; there is typically an associated license with terms permitting redistribution and derivative works 3. While code can be released under an Open Source license by its owner, successful Open Source projects have associated communities of interest [22]. These Open Source communities remain an important factor regardless of the definition of Open Source [23]. For example, the distributed nature of the Open Source Community requires, as a pre-requisite, that the code be modular in order for the community to be able to work on it in a distributed fashion. To ensure process compliance with minimal management overhead, geographically distributed teams require tools for source control management, issue tracking and continuous integration testing.

3 See e.g., http://opensource.org/docs/osd
As with other standardization efforts, Open Source projects can be seen as successful based on the degree of market adoption. This market orientation requires the project to address a real problem that can be expressed as a limitation for the users (not for the developers) of the project. Building a critical mass with an engaged community is a critical factor in successful adoption of the Open Source project. The ability of a community to generate interest and passion is an indicator of their engagement and potential for the advocacy necessary for successful market adoption. To scale the project to a critical mass for both development and market adoption requires resources, e.g. staffing, computing resources, administrative support. Industrial scale Open Source communities often have different grades of membership implying various commitments of staff and funding. Resource-supplying commercial entities have interests in feature control that constrain the community’s liberty to innovate.

The governance structure balances the interests between volunteer contributors, corporate sponsors and users. It also provides the legal context in which the code is accepted from developers and released to the larger community. A successful project provides direction, focus and a sense of purpose to the developers from different organizations, with merit based management within projects. Extensibility frameworks, built into the architecture to enable derivative works, minimize the risk of code forking when the project roadmap stops short at providing value to key participants.

B. Democratization & Socialization of Technology & Markets

When the telephone was invented in the 19th century, it was an extraordinary technological achievement. By the 21st century, improvements in educational levels in society, infrastructure (e.g., Internet), markets and regulations, enable a vast improvement in the range of technologies accessible to the average citizen [24]. Technologies that were previously considered esoteric are now available to consumers. Available curriculum objectives for computer science in K-12 education facilitate programming skills for future generations [25]. The Linux operating system emerged from a hobby into a global collaboration effort involving thousands of contributors. Open Source is no longer a hobby, but now a CIO strategy. The emergence of a market for mobile applications has been enabled by the ingenuity of a much wider range of app developers than traditional Telecom equipment suppliers [26]. Technologies such as Network Function Virtualization (NFV) and Software Defined Networks (SDN) may lead to similar markets for network apps.

C. Emergence of Industrial Strength Open Source Projects Developing Software

There has been an increasing adoption of Open Source software by commercial entities [27]. While Open Source is freely available for developers and integrators, it presents operational challenges in areas such as maintenance and security. When software delivers highly reliable commercial products and services, the cost of maintaining, testing and updating code becomes significant. There is evidence that defects are identified and fixed more rapidly in Open Source projects than in closed source code [28]. Open Source software is claimed to be more secure because the code is available for inspection [29]. Open Source does not mean free-companies have developed business models based upon distributing Open Source software and providing professional integration services. With new business models, Open Source has penetrated industries with industrial scale requirements for security and reliability (e.g. financial services or insurance industries). The value proposition has shifted from lower cost of ownership to faster development/deployment lifecycle.

IV. The Rise of Open Source Industry Alliances in the Telecom Industry

A. Telecom Industry Technology Trends Increasingly Towards Software

Moore’s law and innovations in computer system architectures enable software on generic computing platforms to support workloads with sustained high throughputs [30]. Telecom workloads associated with the data plane of network functions are typically characterized by the high throughput. Multicore computing platforms shift the performance burden from hardware designers to software developers [31].

The convergence of the Information Technology (IT) and Telecom industries has been predicted, practiced and studied for some time [32]. This trend continues with technologies like NFV enabling the execution of Telecom workloads as software in commercial, off the shelf, cloud computing environments. In the IT space, a shift has emerged in the form of Service Oriented Architecture (SOA) [33]. SOA is an architectural approach where business functions are abstracted from their underlying implementations in order to facilitate a more efficient integration of software for business purposes enabling business process optimization and efficient system consolidation. IT/Telecom convergence requires Network Operators to increasingly rely on IT expertise to manage and deploy network functions, and dynamically configure them as end-to-end services on customer request.

B. Software Methodology Trends Increasingly Reflect Agile Processes

In an effort to improve cycle times, mainstream software development methodologies have moved on from a waterfall model to agile methods starting with user stories, rather than specifications [34]. IT organizations have been adopting agile methodologies involving short iterations that deliver business value and allow development teams to adjust quickly to changing or unclear requirements, correct implementation bugs, increase the quality and value of the finished system. The notion of “DevOps” stresses improved communication,
collaboration and interdependence between software development and IT operations [35] to facilitate this reduced cycle time, and, with multiple independent development teams, results in a need for continuous system integration and delivery methods [36].

The agile methodology adopted elsewhere in organizations is making its way into the standards development process. The IETF mantra of “running code and rough consensus”, is applicable to other Industry Alliances as the balance of Telecom technologies shift towards software. Manual interactions in the configuration management, deployment and test of new network functionality (whether new instances or new classes) are an impediment to the timely delivery of service. Operations Support Systems and Business Support Systems have traditionally provided mechanization of processes to support the scale of Telecom infrastructure networks. These systems have assumptions of underlying hardware lifecycles for network function deployments. Virtualized network functions now enable deployment as software. The IT industry has developed methodologies to support the continuous integration and deployment of software into production environments [36]. Standards development activities need to match the timescale of these agile commercial development activities. A waterfall standards development process is mismatched for software ecosystems based on DevOps and continuous integration.

Collaboration tools are playing a significant role enabling the distributed, diverse communities to work together with very little management overhead. Source control systems evolved from basic code management tools into full social networks like GitHub [37]. Communication platforms like Internet Relay Chat (IRC) are key collaboration tools for Open Source projects, IETF, W3C and other Industry Alliances.

C. Motivation for Telecom Industry Engagement with Open Source

There are many reasons businesses consider incorporating adoption of Open Source in their strategy. The development and use of Open Source can be mapped to business agility in service delivery, supplier independence, solution modularity enabling componentization of network functions for virtualization, reduced licensing costs and other benefits resulting from the economy of scale in developing, testing and deploying software solutions.

Growth trends in demand for services from mobile and fixed networks exceed revenue per user trends for the services [38]. Telecom industry technology trends have increasingly favored software based solutions for increasing functionality in order to keep up with constantly updated user requirements. Successful Open Source Projects demonstrate their ability to maintain this kind of velocity by employing software modularity in their architecture and implementations. Traditional Equipment based solutions (that scale with a fixed ratio of capacity and functionality) become uneconomic when traffic demands and service requirements vary beyond initial assumptions. Telecom services have traditionally been deployed in a “siloed” fashion because the services were bound to specific infrastructure nodes and technologies; the trend, however, has been towards breaking these silos and decoupling the services into multi-tenant environments [39]. Using an Open Source modularity approach towards the virtualization of network functions allows for the flexibility needed to compete efficiently in the market place. The economy of scale from shared infrastructure with the IT industry eliminates many of the inefficiencies resulting from the loss of specialized optimizations.

Technology research has enabled a number of improvements in Telecom industry equipment. SDN decouples the control of the connectivity from the physical node topology and NFV enables automation of end-to-end services across a distributed computing environment. Research is increasingly providing results as Open Source artifacts rather than purely theoretical papers [40]. Commercial entities in the Telecom Industry need the skillsets and procedures to evaluate, industrialize and deploy such solutions.

Deregulation has resulted in increased competition, a greater degree of internationalization as well as new providers of services and products (e.g. from the IT industry) [41]. Service innovation is emerging as a regulatory policy objective [42]. Telecom service providers are challenged with rolling out faster and more reliable infrastructure while delivering compelling services to compete with the new Internet based services.

Service innovation is increasingly seen as being enabled by the choice of the appropriate software platform [43]. Service innovation requires agility - the industry cannot afford release cycles measured in years; a more iterative, pragmatic and concrete approach is required. The IT industry has moved towards agile methodologies pushing the software development and deployments into cycles of days and weeks; the Telecom industry is now moving in that direction.

D. Challenges for Telecom to use Open Source

There are a number of challenges in the use of Open Source software by commercial entities [44]. The adoption challenges in Telecom services include technical requirements like low latency and high availability; but also commercial resistance from an existing ecosystem, long-standing operational procedures associated with upgrades, and the waterfall approach to develop and publish Telecom standards then implement, test and deploy equipment.

The governance arrangements for the Open Source Community strike a balance between a continuum of anarchy democracy/meritocracy and traditional commercial organization. Managing the degree of openness of the technology platform encourages both developer engagement and platform adoption [45]. Network Operators have not traditionally engaged in the governance of Open Source projects, though they may be engaged in governance of other Industry Alliances. Network Operators have not traditionally had staff engaged as members of Open Source communities,
because the Open Source code that they have used has typically been embedded within some other commercial product offer. Traditionally the Telecom Industry infrastructure was built around a RAND licensing model. While the model is unlikely to radically change, corporations need to consider carefully the differences between Open Source copyright and IPR licensing, for code that they use, extend for their own use, sell as part of products, contribute to Open Source communities, and further contribute back to upstream Open Source communities. Commercial entities that have not previously been engaged with Open Source communities need to develop the appropriate policies to support such interactions [46].

Open Source adoption challenges Network Operators in the shift from buying to building and evolving a base of Open Source infrastructure software. The market and industry trends towards service development agility require new skillsets and tools to facilitate an agile software development environment. Competitive Telecom services markets do not preclude collaboration with other industry participants in the development of such an Open Source platform. Commercial entities engaged in Open Source development need to develop organizational structures and policies to delineate the scope of functionality (and intellectual property) between proprietary and Open Source so as to avoid contamination issues.

E. Challenges for Open Source from Telecom applications

The incorporation of Open Source into Telecom infrastructure will create some challenges to the Open Source model as well. Telecom infrastructure typically has a long lifetime, and so Open Source communities that support Telecom infrastructure will need mechanisms to sustain themselves and their projects over these time scales. Open Source projects have typically evolved based towards new functionality. The Telecom infrastructure applications have traditionally required an emphasis on performance, security and reliability. Open Source communities may need to develop mechanisms to encourage and sustain improvements in these dimensions, not just in additional functionality.

The use of Open Source software in high availability/high reliability and high traffic environments as an essential building block for the network infrastructure will mandate for the code to be tested for resilience. It will also push development towards efficiency and optimization resulting in higher quality software for all parties involved which in the end should be serving the “common good.”

The Telecom industry provides opportunities for Open Source projects to “fill the gaps” by integrating independent Open Source community projects into coherent platform releases for large scale distributed, heterogeneous systems. An Open Source platform establishes a baseline of functionality (e.g. kernel, networking, storage primitives) available for application development. The functionality of that baseline can evolve over time as the industry adopts new capabilities (e.g. common APIs and abstractions for various accelerators).

F. Industry Alliances recognizing the trend

As Open Source has become mainstream, some Industry Alliances, including more formal SDOs, are now experimenting with Open Source projects [3]. Some Open Source projects now target Telecom industry applications [4]. Some Industry Alliances are also embracing Proof of Concept activities to inform the development of their specifications [47]. As agile development methods become mainstream, this creates pressure for corresponding changes in other processes within commercial firms and at Industry Alliances, in order to match the timescales.

Intellectual property rules are evolving both in the legal systems and in Industry Alliances, including some of the more formal SDOs [48]. This is reflected in updates to their IPR rules, governance, tools and staff expertise. Industry Alliances are increasingly recognizing the need for outreach to the research community to enable open innovation. Such outreach may include procedural improvements that enable more direct participation by researchers and publication by industry of technology roadmaps, research agendas, grand challenges, etc.

V. CONCLUSIONS/RECOMMENDATIONS

Industry Alliances create and build ecosystems around technology platforms, typically through specifications. Open Source communities build ecosystems around technology platforms and can be considered a form of Industry Alliance. Because it is available for immediate testing and prototyping of applications and extensions, Open Source code is easier to adopt, and validate the utility of, than a specification. Validation of the utility of the solution leads to more effective ecosystems, sooner. Industry Alliances should consider also building Open Source communities, not just paper specifications. Industry Alliances can facilitate the dialog with research by revising procedural mechanisms to enable participation and increase communication with the research community. Industry Alliances should also review their IPR rules to consider the development of Open Source projects and communities.

Ecosystems based around technology platforms provide commercial advantages for participants. Industry Alliances (including Open Source communities) build ecosystems around technology platforms. Network Operators, and others, participate in Industry Alliances to build ecosystems around technology platforms. Network technology platforms are increasingly software based and influenced by Open Source communities. Researchers can be more influential when their Open Source research artifacts are targeted towards Industry Alliances. Commercial entities participating in Telecom


6 See e.g., http://www.OpenDaylight.org
ecosystems, including Network Operators, should consider selective participation in Open Source communities that provide technology platforms to facilitate their business interests.

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