

IEEE Software Defined Network Initiative

A Proposal

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Abstract — This paper outlines a proposal for setting up an IEEE initiative on software defined networks (SDNs) to facilitate professional and academic exchange of SDN-related ideas, research, and development. The proposal is a result of an intensive effort of a team consisting of the authors. After a comprehensive gap analysis, gaps and key opportunities were identified. Finally, a specific set of components along with schedule and financial consideration were proposed in the areas of publications, conferences, standards, education, certification, and publicity.

Keywords—*SDN, Software Defined Networks, Virtualization, IEEE, Abstraction.*

I. INTRODUCTION

Software Defined Networking (SDN) has become one of the most active research areas in networking and communications today. There is a flurry of activities in the industry and academia and yet, there is no major professional organization leading the way in a substantial and comprehensive way. This prompted IEEE Communications Society and IEEE Future Directions Committee to set up a task force to propose an IEEE initiative to make the IEEE as “the place to go” for any SDN related activities such as publications, conferences, and standardization.

The authors of this paper formed a task force to prepare a proposal, which is the subject of this paper. The team members shared the load, each taking on a specific area of the proposal. The team met on a weekly basis to discuss the findings and future directions. The methodology used by team was straightforward: perform a gap analysis by reviewing current activities, different interpretations of SDN, and related technologies such as cloud computing, and identify overlaps. Then, identify the gaps, open areas, and key opportunities in general. Finally, identify opportunities for IEEE in the areas of publications, conferences, standards, education, certification, etc.

It was quickly determined that there are different views on SDN and the well-known interpretation [1,2,3] is rather limited! Despite the existing activities, we emphasize that the field is just emerging and will grow quickly. The related technologies such as Cloud Computing, Cognitive Radio Networking, are not threat to SDN. On the contrary, SDN can be a strong enabler for other emerging technologies due to its significant flexibility and overarching scope.

An important finding of the team is that there is a need to broaden the vision of SDN to cover all components end-to-end, and to include all types of technologies (wireless, optical, etc.) involved. This broader vision is especially important for IEEE to fill the gap and provide a larger scope for its products in publications and conferences.

The primary objective of the proposal is to establish an IEEE-wide initiative with a comprehensive program based on a broad vision of SDN. The proposal emphasizes a prioritized launch of products and services to utilize resources efficiently. Accordingly, the mission of the proposal includes keeping up, leading, and co-branding as much as possible with other IEEE and non-IEEE activities. The highlighted individual areas are as follows:

- An IEEE Magazine on SDN and a Journal on SDN
- A major conference and regional and topical conferences
- A Standards Committee on SDN to drive standardization
- Tutorials, e-courses, training courses, and webinars
- Certification programs for people, devices, and testbeds
- Web Portal for links to IEEE SDN programs, repository, communications

The rest of the paper provides a detailed vision of the future of SDN. Section II provides a summary of the analyses and opportunities identified by the team. In Section III, the individual components of the proposal are presented. The management issues related to the initiative are discussed in Section IV. Finally we conclude the paper in Section V.

II. ANALYSES AND OPPORTUNITIES

SDN has become widely accepted as a new paradigm in designing network(s) and their components. Technology and market trends have enabled an open framework to create modular networks that can be functionally separated, to achieve user, application and service awareness; manageability; and controllability. Ability to use abstractions allows programmability and open innovation and separation of basic hardware from various control and management functions.

SDN started with a narrow scope of separating data and control planes, but it is evolving [1, 2, 3]. SDN can be used in generalized areas of networking (User Equipment (UE), Radio, Transport, Application) abstractions that allow management [17], cloud, cognitive, and smart grid [4, 5].

SDN's key characteristics include: Modularization of Hardware, Software, and Functions, Multi-Level Virtualization, Multi-Tenancy, Centralization of Control, Programmability, and Open Innovation.

There are numerous SDN related events under way, including standardization, conferences, and industry alliances. OpenFlow is the most widely known standardization activity in this area. It is an interface specification between a path controller and a data forwarding engine. In addition to Open Networking Foundation (ONF) [6, 7] (the defacto home of the OpenFlow specs.), Internet Engineering Task Force (IETF) [8, 19], Open Daylight [9], Distributed Management Task Force (DMTF) [10], Open Management Group (OMG) [11], Association of Computing Machinery (ACM), European Telecommunications Standards Institute (ETSI) (most active in Network Functions Virtualization (NFV) [12]), Optical Internetworking Forum (OIF): [13], as well as IEEE are some of the other organizations that have some SDN activities.

There are several technologies that seem to relate to SDN, but it is clear that SDN is not a replacement of those, but rather a facilitator to make the implementation of the those technologies easier. Briefly, Cloud Computing refers to the use of computing resources delivered as a service over a network. SDN framework is increasingly [14] adapted in cloud computing/networking [17]. Cognitive Networks refer to those networks with cognitive processes that can learn from the past and use this knowledge to improve the decisions in the future. For Cognitive Networks, SDN can provide mechanisms to support self-learning and self-adaptation and the autonomic network management needed by cognitive networks [15]. Similar arguments can be extended to Service Oriented Architectures (SOA), Network Functions Virtualization (NFV), Application Programming Interfaces (API), etc.

Our analyses reveal that there are indeed a large number of gaps; that SDN provides opportunities not only for IEEE, but the whole academic and industrial world to explore. These include creating and using abstractions, Information Centric networking (ICN), new programming capabilities/models, SDN for Network Management [17], SDN for Self Organization Networks (SON) [20], SDN for IEEE created technologies (e.g., Ethernet, WiFi). SDN Support for Open Application Innovation and Business Models, as well migration between different SDNs and migration to SDN from legacy networks are also important opportunities [21].

Furthermore, SDN will impact networks evolution both in the core and in the edge (i.e., access, distribution) segments. The edge is arguably the network segment where SDN innovation will be exploited more disruptively. On the other hand, the edge will become smart and much differentiated. Software will become a powerful enabler to create dynamic interoperability of multiple pools of processing, storage and link resources (here and now). There will be a change of paradigm in the business: from centrally managed networks to

application-driven networks, from Quality of Service (QoS) to Quality of Applications.

Telecommunications sector is going through a very significant change, for several reasons (regulations, costs reductions, larger competition, etc.). It will be important to point out that the SDN will be a major driving force in the current and future regulation scenarios of the sector. It will be also necessary to analyze these scenarios and simulate the cooperation-competition among diverse players like N.Os, OTTs, but also Municipalities, Providers of Consumers Electronics, Enterprise Networks, etc.

Our gap analysis also reveals that a broader vision, a broader framework can be used to create an ecosystem, which may include: User Equipment (UE), Radio [23], Transport, Application, network management, cloud, cognitive, and smart grid.

The broader vision will apply to many different segments of a network such as wireless networks [22], optical networks as well as different architectures such as service oriented architectures, and the management plane (E2E automated control of business by BSS and OSS). Most importantly, the broader vision for "Software Defined-concept" will be very important for IEEE to base its activities in publications, conferences and standards

III. COMPONENTS OF THE INITIATIVE

The components of the initiative are identified along the lines of IEEE's strength areas: conferences, standards, training/education, and certification. The initiative will also have an additional component to supplement these strength areas: Web Portal and Communications.

A. Publications

A quick analysis indicate that there is no dedicated venue for publications in SDN today; neither IEEE nor otherwise. There has been some feature issues in the past in IEEE Communications Magazine [16] and in Springer Journal on Network and System Management. Therefore, SDN needs a publication outlet to bring together a sizeable SDN research community from various outlets (conferences, workshops, journal special issues and series). We need to make sure a dedicated journal will be sustainable since much of the interest seems to be driven from industry; but the interest from academia has been growing exponentially.

The initiative includes a magazine style publication, called IEEE SDN Magazine. High interest is expected from researchers and even more so from industry. It will create a forum for SDN researchers, developers, Open Networking Summit – type audiences. It will balance new topics and survey-style articles. The plan is to begin with a quarterly magazine in the first year, and increase the frequency in later years.

The initiative also includes journal publications. The plan is to have special issues on SDN on existing venues such IEEE Communications Magazine and IEEE Transactions on Network and Service Management. A new SDN Series in IEEE Journal on Selected Areas in Communications (JSAC) will be

launched immediately. The plan is to start with two dedicated issues per year and ramp up to 4 issues in the second year. This will serve as incubator for a new IEEE Journal on SDN. There is a need to establish at least one journal as the “place to go” for archival quality SDN papers. Based on response / submission numbers, early experiences with SDN JSAC series, SDN magazine, special issues, conference/workshop publications/workshops publications on SDN, an IEEE journal will be launched during Year 3 of SDN Initiative. The plan is to publish four issues a year initially and ramp up to more based on expected increase of paper submissions due to visibility offered by a journal dedicated to SDN research.

The initiative plans to leverage IEEE Press/Wiley book series to publish a set of books on SDN. Since the topic is in flux now, books only on certain point topics (e.g. Openflow) are expected to be published. These can be edited books with chapters contributed by field experts.

B. Conferences

The current landscape shows us the following: There are several existing events dedicated to SDN including a number of industry summits such as Open Networking Summit (Oct. 2011, Apr. 2012, Apr. 2013), China SDN and Open Networking Summit (Dec. 2012), SDN Summit (Mar. 2013), SDN World Congress (Jun. 2013), SDN & NFV (Oct. 2013), and SDN Asia (Dec. 2013). There were a number workshops on SDN as well: HotSDN: ACM SIGCOMM Workshop on Hot Topics in Software Defined Networking (Finland – Aug. 2012, Hong Kong – Aug. 2013), SDN: IEEE ICC Workshop on Software Defined Networks (Canada – Jun. 2012), and EWSDN: European Workshop on Software Defined Networking (Germany – Oct. 2012, Germany - Oct. 2013). It is important to note that three have been numerous panels, tutorials, papers and plenary talks at general systems conferences: mainly ACM and USENIX sponsored events (e.g., SIGCOMM, NSDI, OSDI, NDSS, IMC, CoNext, HotNets, HotICE, PAM, etc.), and a few are IEEE sponsored (e.g., IM, NOMS, CNSM, INFOCOM, ICC/GLOBECOM).

One can easily conclude that IEEE needs to play a more active role in SDN-related events worldwide. There is little IEEE presence so far including a few dedicated workshops: SDN Workshop co-located with ICC (2012) and European Workshop on SDN (EWSDN'12) and a few general purpose conferences: only a few compared to other learned societies/organizations, namely ACM and USENIX.

There is a great potential for IEEE led conferences, workshops, and forums: ACM SIGCOMM HotSDN 2013 attracted 86 paper submissions (will NOT continue beyond next year per SIGCOMM policy); SDN tutorial at IEEE IM 2013 attracted over 75 registered attendees; worldwide industry SDN adoption; increasing interest in academia judging by the number of grant proposals; and no major SDN conference venue today, neither IEEE nor otherwise.

Based on the above assessment, the initiative proposes the following 4 category of conference activities:

- Sponsor SDN related activities in IEEE Conferences: This should include keynotes, technical sessions,

panels, tutorials in IM, NOMS, ICC, GLOBECOM, INFOCOM, etc. Also it includes workshops in conjunction with IEEE Conferences such as IM, NOMS, ICC, GLOBECOM, INFOCOM, etc. Industry Forums and Industry Exhibits on SDN could also be part of ICC, Globecom, IM, NOMS, etc.

- Launch "Annual IEEE World Conference on SDN": This would be positioned as the flagship IEEE conference on SDN. High interest and attendance from academics and the industry are expected.
- Sponsor IEEE Regional conferences and workshops in Asia Pacific, Europe, and Latin America.
- Sponsor IEEE Topical SDN Conferences/Workshops on Software Defined Radio, Software Defined Optical, Software defined Data Centers, etc.

C. Standards

Many efforts are underway by major Standards Developing Organizations (SDOs) principally in requirements analysis (SDN-SP, POMI, ETSI/NfV, IRTF SDN, IETF SDNP, and OSU) and few standards specification (OpenStack, NIST, IEEE NGDON, OpenDaylight, ONF -F, IWWW 802, SDR Forum, OMA DM2) for enabling the SDN.

There exists a large gap in realizing the SDN, primarily because the standards landscape needs more focus. There is high potential to apply Software Defined Standards in enabling business cases/applications for Smart Grids, Entertainment, Health, Finance, etc. The following is a snapshot of the hot areas in the next 3 years for standards in Software Defined Ecosystem:

- User: Virtualization of Customer Equipment Functions; Centrally controlled automated P2P relations for Wireless Adhoc Networks. Dynamic detection and attachment of User sessions in a Het Net; Emerging research in programmable machines (movable parts) (Creating custom antenna function, user tracing antennas, vehicle networks, etc.).
- Transport and Access: Global Flow control through flow control negotiations among providers.
- Service and Control Infrastructure: Virtualization of service functions for enabling programmable service delivery and operations.
- Application & Management: E2E automated control of business by BSS and OSS. Business orchestration to dynamically create Network orchestration.

To take advantage of these opportunities, the initiative will set up a Software Defined Ecosystem (SDE) Standards Committee to promote, co-ordinate, collaborate and accelerate focus on SDE Standards. Also support the standards development through IEEE-SA. The responsibilities will include providing IEEE SDN Standards Representation in Global Standards Collaboration (GSC) - proposing a Question on SDN and Collaborate on Global Standards, identify a subset of these organizations and their thought leaders and establish a collaboration board around SDE.

The IEEE SDN Standards Committee will be created with major industry and academic players. This committee will be instrumental in creating the PARs for IEEE SDN Test Bed, in extending the scope of existing IEEE Standards Initiatives – 802.x, P1903.x, etc., in supporting the Standards Boards in various IEEE societies to create and support new PARs in SDE domain (CPE, App interface, Management, INTEROP) and provide relevant technical support, as well as in enhancing participation in Standards by collaborating and publicizing with IEEE Regional Chapters.

IEEE SDN Initiative Standards Committee will be responsible to setup SDE Technical Advisory Group (TAG) to build the E2E SDN blue print for various Operators (Carriers, MVNO, ISP, App Provider, etc) for implementing end to end SDN based on world wide standards. TAG will provide a test bed to support validating or certifying the products based on these standards to help the certification of the E2E SDN implementation both for operators and vendors. Based on business demand support for additional TAG spin-offs (Eg. SmartGrid-SDN TAG, Data Center-SDN TAG, Carrier-SDN TAG, etc) will be provided as well. And eventually, transfer the activities to relevant IEEE Technical Societies like ComSoc, SA, Computer and others will be coordinated by TAG as well.

Setting up and maintaining a SDE knowledge repository (website) for next 3 years of world wide efforts in SDN specifically from Research and Standards aspects will be done in coordination with the IEEE SDN Web Portal. This will support in publishing SDN business case study white papers and publications from IEEE SDE Standards Committee.

Promotion of IEEE SDE Standards by supporting commercial demonstrations by operators in key events (IEEE and non-IEEE) by providing logistical support will be among the other activities of this committee.

D. Training/Education

Existing educational events dedicated to SDN include various tutorials given at conferences such as ONS (Open Networking Summit), ACM/USENIX/IEEE sponsored conferences and some online tutorials such as SearchSDN.com, Bay Area Network Virtualization. There are also several education and training courses, most notably by "SDN University", SDNCentral. The format varies and includes free webinars, paid webinars, on-site training. SDN Academy also offers education courses and on-site training. In addition, there is Georgia Tech free online course on SDN offered via Coursera.

IEEE needs to play a more active role in SDN-related education worldwide by providing a set of comprehensive SDN-related educational activities online and in local regions including developing regions and by providing systematic training for supporting certification, standards, and testbed related activities.

Based on the above assessment, the initiative proposes the following four category of educational and training activities for IEEE:

- Provide a set of comprehensive face-to-face and online short (2-3 hours) tutorials and webinars on SDN. This may include introductory, intermediate as well as advanced tutorials on SDN and SDN related topics. Online tutorials could be once a month. The face-to-face tutorials could be part of the major conferences. Some examples of topics include: Introduction to OpenFlow: standards, current development, and open research issues; Overview of SDN: SD-related research and projects; SDN Framework and Functional Components; Current activities in SDN standardization
- Provide online and face-to-face day-long (6-8 hours) learning courses. These include training courses and education courses that could be targeted for certification, for standards, and for test-beds as well.
- Integrate/collaborate with other components to make IEEE SDN training and education activities more meaningful and practical for the industry. The collaboration with Portal activities will increase public awareness, broaden audience to SDN via Facebook, Twitter, magazine/newspaper. Tutorials, eLearning courses, and Webinars will be publicized through the portal, which will also be useful in collecting potential interested topics for tutorials, eLearning courses, webinars, and summer schools. Collaboration with Publications and Conferences activities will help publicize eLearning courses in IEEE publications. Also, obtaining videos of conference talks (keynote, distinguished talks) and tutorials for Webcasts, online tutorials, and education courses will be very helpful in creating a portal warehouse for SDN material. Finally collaboration with Certification, Standards, and test-beds activities is essential to develop training/education courses: e.g., certification curriculum, certification classes.
- Provide education and training activities for IEEE local sections/chapters. These could be handled by interacting with the Distinguished Lecturer Tours and sponsoring humanitarian talks in developing regions and 1~2 summer schools around the world.

E. Certification

It seems that there is very little certification related activities on SDN. There is Cisco Certified Network Professional (CCNP) Service Provider certification program, which is aimed at developing the skills and knowledge of IT professionals to deploy and next-generation networks; not specifically tailored for SDN. There is also Indiana University's InCNTRE Lab, which is a certification lab for Open Flow.

Certification for SDN is definitely a fertile area! This is a great opportunity for IEEE to get into. IEEE can provide certification in the following three areas:

- Professional Certification: This may consist of the establishment of Body of SDN Knowledge (BoSK); creation of BoSK Learning Tools which should include the curriculum, books, newsletters, classes, as well as the support. In addition, development of BoSK

Examination Tools including SDN-P Certification Exam and Renewal is needed.

- Device Certification: This will require that device requirements, SDN-D Specs, application areas, and benchmarks need to be developed by solicitations and interactions with the industry. Revisions need to be managed. Also, evaluation tools for SDN Certification test bed, SDN-D Benchmark tests, and SDN-D Certification need to be established. The process for certification renewals needs to be established as well.
- Internal SDN-test bed development: Certification procedures should be developed based on the initial test bed evaluations. Implementation of a test bed via Internet 2.0 and local data centers/supercomputer centers is necessary to utilize state-of-the-art resources. Education activities will be included in the SDN-test bed for education/curriculum activities. Third party requirements which require SDN Testbed specs and heavy Industry relations need to be established. Finally, an evaluation board for testbed certification need to be formed for managing SDN-T Re-evaluation-Renewal-Expiration-Cancellation activities.

F. Web Portal and Communications

Publicity and presence of a well developed, user friendly web portal are two essential ingredients for the success of any initiative. Currently, there is only one independent SDN portal (SDN Central). Other portals are all either company owned or standards body specific: Open daylight (Cisco-IBM led), Company specific portals: SAP, Jupiter, Cisco, etc. Standards Specific: OpenFlow, Open Networking Foundation.

The SDN portal will be an essential infrastructure for the IEEE initiative, which is needed to provide support broad based interpretation of SDN, to become a “store front” for an easy access to all IEEE SDN Initiative programs, to publicize IEEE SDN related activities, to be repository of SDN specific materials (videos, presentations, documents, etc), to provide a platform for SDN specific job postings, news, events, etc. And furthermore the portal has a great potential for revenue generation through ads.

The SDN portal will have links to all IEEE SDN activities. It will be a user interface to access to IEEE SDN products and services. It will include SDN related news, SDN related job posting, and advertisement (banners, buttons, context sensitive ads, etc.). The portal will be the clearinghouse for all SDN related presentations, videos, documents, etc. The portal will be integrated with social media such as Facebook and Twitter.

The development of a portal is time consuming and expensive. But, the presence of a portal is essential as soon as possible to support the other components of the initiative. A phased development approach is the key to speed up the launch of the portal as early as possible.

Communications is an important aspect of this initiative. We need to place IEEE on the SDN map and for this we should have a strong communications component, which includes marketing, public relations, and public visibility. Web Portal is an important component of this component. Other

communications related activities include: Social Media, Co-Branding, co-sponsoring activities in related events, and advertisement in other SDN portals and other publications.

IV. PROJECT MANAGEMENT

The project management part of the initiative provides an insight into its milestones and schedule, estimated expenses, potential revenues and how the initiative will be managed. The proposal includes a specific organizational structure which consists of an executive committee for day-to-day operations of the activities as well as a steering committee to oversee and make fundamental decision on the operations. The schedule proposed takes into account of the fact that prioritized launch of products and services is necessary to utilize resources efficiently and to keep up with and to lead the community, and utilize co-branding as much as possible.

The proposal also established certain rubrics to measure the success of the initiative. For publications, the number of submissions, the number of downloads, and advertising revenue will be the criteria. For conferences, the number of attendees and the surplus will be the keys. For standards, the number of PARs, number of members in each WG, and number of companies participating will be the basic criteria. For education, the number of attendees; for certification, the number of applications, and for the portal, the number of visits, number of downloads, and advertisement revenues will be used as the basic criteria to measure success.

We recognize that there are numerous challenges. Predicted interest in academia may not materialize. Then a shift from journals to more industry oriented publications may be necessary for publications. Moreover, a shift from academic conferences to more industry oriented conferences, meetings and events may be necessary as well. Industry may not be interested in IEEE standards and again, the predicted interest may not materialize which will impact the education and training components as well. The need for certification is closely tied to the acceptance of the SDN technology in general. The challenge for the web portal would be that we need to make it attractive enough (content and appearance) to catch attentions and draw advertisers; make it user friendly and useful.

V. CONCLUSIONS

This paper describes a proposal which is a result of an intensive effort by a team of experts supported by an advisory board. This is a comprehensive proposal for an IEEE-wide initiative on Software Defined Network (SDN), which is a new paradigm in designing networks and its components

The report includes a gap analysis on the field and related technologies and associated activities in publications, conferences, standards. The report also identifies opportunities and specific proposals for IEEE in the areas of publications, conferences, standards, education, certification, and web portal. The report proposes a 3-year program with a specific schedule, milestones, and estimated budget.

We conclude that there is a need to broaden the vision of SDN to cover all segments of a network (i.e., end-to-end), and

to get all types of technologies (wireless, optical, etc) involved. This broader vision is especially important for IEEE to fill the gap and provide a larger scope for its products in publications, conferences, etc. It is essential that we establish an IEEE wide initiative with a comprehensive program based on a broad vision of SDN in order to make the IEEE a major player in this field.

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