



TRENDS OF OPEN SOURCE SOFTWARE IN MISSION CRITICAL ITS SERVICES INFRASTRUCTURES ADOPTION IN LOCAL ENVIRONMENT

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Abstract

OSS (Open Source Software) is a leading-edge technology which has a profound impact on Information Technology. It has been observed via extent research that there are substantial barriers associated with OSS that thwart the wide adoption of OSS especially in the domain of mission critical software. Critical IT infrastructure is the backbone of any country. Any nation's economy, security, and health are totally dependent on the critical infrastructure. Critical IT infrastructure demands mission critical software to run their day to day work properly and efficiently. It has been observed that critical organizations are operating with proprietary software and are willing to adopt Open source software (OSS). Proprietary software comes with many issues like vendor dependencies, license cost and maintenance cost. This paper investigates the current trends of Critical IT infrastructure and identifies the barriers in OSS adoption in Critical IT Infrastructure Industry.

Keywords : Open Source Software, Closed Source Software, Factors affecting adoption, Information Technology.

I. Introduction

Revolution in Information technology introduces Open Source Software (OSS) by which individuals and organizations can utilize software for free, they can learn and understand the internal workings of the software and also revise it as per their requirement. Over the last decade Open source software has created significant

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anticipation in the business world [V]. The major benefits achieved by organization through open source software usage is simultaneously increasing in the level of security by extensive community participation and software capabilities by reduced operational IT expenditures. OSS provides a product that has rich features, low total cost of ownership and tightly coupled with business standards which in turn add considerable return on investment to an organization. OSS advantages led governments around the world to adopt in their public infrastructures [XVII].

It has been observed that the share of proprietary software has gradually been decreasing with time, and many organizations rely on open technologies [VI]. OSS software has become de facto standard for developing new product and services example Linux Operating system and Apache HTTP Server [XIII]. Future of Open Source Survey 2019 concluded that open source forms the backbone of the most significant projects in today's development organizations [XXIV]. Growing Ecosystem of Infrastructure providers and cooperate supporters (GitHub.com & Red Hat Inc) facilitate the growth of OSS [VII].

It is very important to understand the difference between critical systems and non-critical systems. Critical systems are highly reliable systems that have round-the-clock support with near zero downtime requirements, failure of which will result in serious consequences to the organization. Whereas, non-critical systems have low reliability with limited support, any failure does not have a major impact on the organization operations. Critical sectors emphasize on mission-critical software that is essential for businesses or organizations to survive. Critical sectors must follow more rigid processes regarding risk, security, and compliance as compared to non-critical systems.

New technology adoption into organization is a challenging process that needs to be carefully considered [VII]. Open source software adoption in critical sectors is very crucial. Critical sectors include ISP, Health care, financial services etc. Critical sectors emphasize on mission critical software that are essential for businesses or organization to survive. Mission critical software failure brings company operations on halt. Mission critical software includes Enterprise resource planning (ERP), Electronic Medical Records (EMR), Electronic Health Records (EHR), Customer relationship management (CRM), Banking software, airline reservation, railway/aircraft operating system etc. Table 1 shows the Critical infrastructure considered in this study.

Table 1. Critical Infrastructure

Communication (ISP-Internet Service Provider)
Financial services (banking, clearing)
Health Care Services
Government Facilities Sector

Transportation Systems Sector (railway, Bus network etc)
Gas& Oil Storage Services
Water and Wastewater Systems Sector Company
Security services (police, military).

This article investigates the current trends and identifies the factors which serve as a barrier to OSS adoption in critical IT infrastructure. The rest of this article is ordered as follows. Section 2 presents the methodology that has been used to identify the current trends of OSS adoption in critical IT infrastructure. Section 3 discusses the results of the survey. Finally, section 4 presents the conclusion and future work of this research work.

II. Methodology

A combination of quantitative and qualitative research techniques was utilized to obtain insight into the current situation of OSS use in the region.

First important factors were identified and then questionnaire for OSS adoption was constructed which discuss issues such as reason of OSS adoption, avoiding piracy, low cost, working experience, advantages, disadvantages, problems, quality, future expectation and integration with proprietary software. Several factors have been covered in the questionnaire, which required the respondent to give his/her.

Opinion over different facets of OSS adoption in their organization. The majority of organizations working in Karachi with a stable IT department and diverse area of operations are included in this research survey to allow an in-depth study.

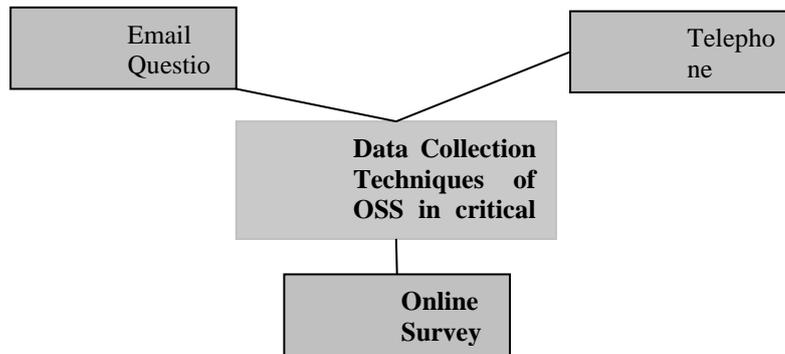


Fig. 1: Data Collection Methodology

For the quantitative method, a total of 40 structured interviews were completed. The qualitative methods included group interviews from the organizations, where key stakeholders as forerunners in the use of OSS and persons who were enthusiastic to operate/use OSS were invited for group interviews. These Organizations were already using OSS and through the unstructured interview, it was attempted to find out why

they were using OSS, how it was initiated, what the main factors of success were, what problems were encountered during the implementation and maintenance and what problems they see in OSS based systems or environment. These informal discussions were conducted to obtain more in-depth information on how to promote OSS use, what constraints could be overcome and possible future directions were sought. Based on the estimates and the actual number of completed interviews the response rate was calculated to be 85%. The total sample size is 120 out of which 110 were usable responses.

Table 2: Survey Structure

Total Sample Size	120
Accepted Sample	110
Response Rate	91%
Method	Quantitative
	Qualitative

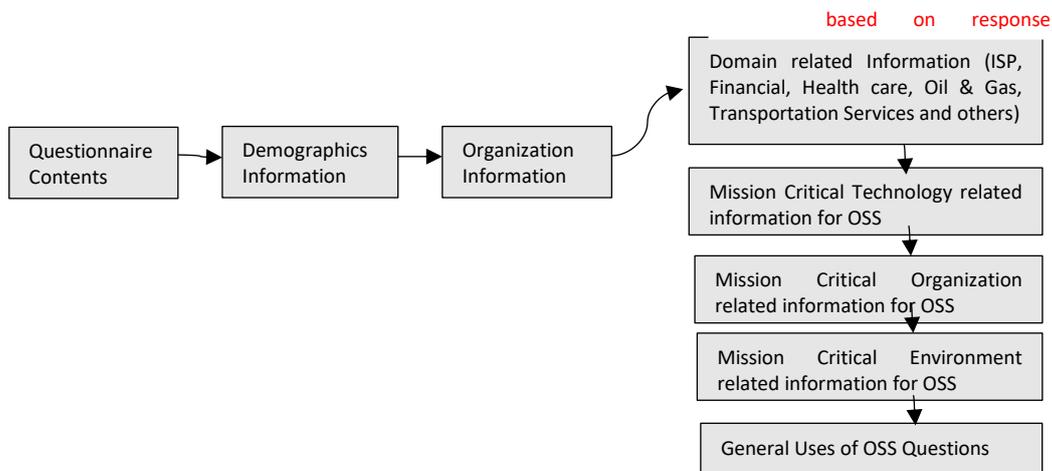


Fig. 1. Survey Flow Diagram for OSS Adoption in critical IT Infrastructure Industry

III. Results & Discussion

The study examined the adoption of OSS for Mission-Critical IT Infrastructures to analyze the effect of Intrinsic factors, technological factors, and external factors on the adoption of OSS in mission-critical IT infrastructures. A questionnaire for OSS adoption was constructed to identify the issues in Mission-Critical IT Infrastructures that influences the adoption decision and was available

online. The semi-structured questionnaire was constructed using the Likert scale ranges from 1-5, type of statements, ranges from 1 denoting ‘Strongly Agree’/‘Very Important’ to 5 denoting ‘Strongly Disagree’/ ‘Not Important’). The questionnaire focused on an individual from organizations, who had a good understanding of OSS usage in the critical-sector.

Results of the Questionnaires

Of the 120 total respondents, a total of 110 IT executives completed the survey shown. The demographics of the sample were as follows (see Table 3). Out of 110 participants, 93 were men (84.5%) and 17 were women (15.5%); the average age of the participants was between 30 -40 years. In the case of education, bachelor degree graduates accounted for the largest share of 74 (45.9%). Approximately the majority of the respondent 66 (60%) in the survey had good ICT knowledge/computer expertise. In terms of length of service between 5 and 10 years represented 45.7% of the total respondents. Most of the participants were Managerial professionals / Engineers 95 (86.3). The majority of the participants belonged to the organizations with more than 100 persons 79 (71.8) and were part of the public sector 65 (59.1).

Table 3: Demographic Information

Demographics Profile		Frequency(N)	%
Gender	Male	93	84.5
	Female	17	15.5
Age	<30	36	34.2
	30-40	59	56.1
	41-50	8	7.6
	>51	2	2
Education Level	Others	4	2.8
	Certificate	15	9.3
	Diploma	6	3.7
	Bachelor	74	45.9
	Master	57	35
	PhD	5	3.1
Level of Computer Expertise	Novice	5	4.5
	Intermediate	39	35.5
	Expert	66	60

Current Job Position	ICT Manager / Engineer	95	86.3
	Director/CEO	5	4.5
	Consultant	4	3.6
	Analyst	6	5.4
No of Employees in Organization	not more than 5 persons	4	3.4
	6-20 persons	13	11.8
	21-100 persons	14	12.7
	more than 100 persons	79	71.8
Organization Sector	Public	65	59.1
	Private	45	40.9

Domain Specific Information

This study provides insight into the factors influencing the adoption of open source mission critical software in Critical Infrastructures. The survey has been given to the IT experts belong to different of critical sectors. Their response is being discussed in this section. Approximately 69.4% of respondents claim that they are using OSS in their office/home, shown in figure 2. Many of the respondents approximately 10% belongs to ISP sector. OSS products that are implemented in their organization for Network monitoring and network graphing are depicted in figure 3. It has been observed that Open NMS has been utilized by approximately 50% by ISP’s.

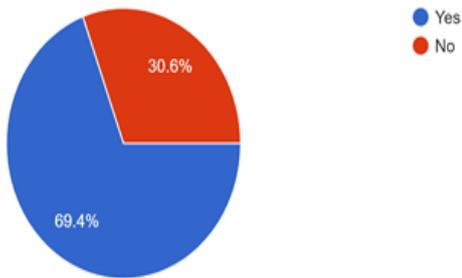


Fig. 2. OSS utilized by respondents

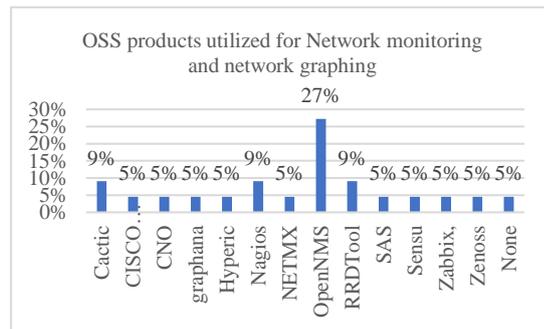


Fig. 3. OSS products utilized for Network monitoring and network graphing

OSS applications are first, second or third running products in terms of market share in several markets, including server operating systems, web servers, desktop operating systems, web browsers, databases. It has been noticed considerably that

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Apache HTTP Server takes the major market share i.e approximately 38% as depicted in figure 4. Figure 5 shows that people are now considerate to adopt OSS CRM and Free CRM has been utilized by 20% of respondents.

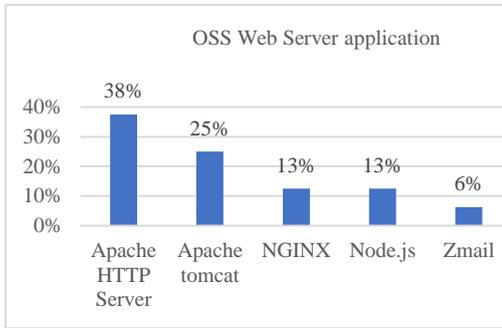


Fig. 4. OSS products utilized for Web Server Applications

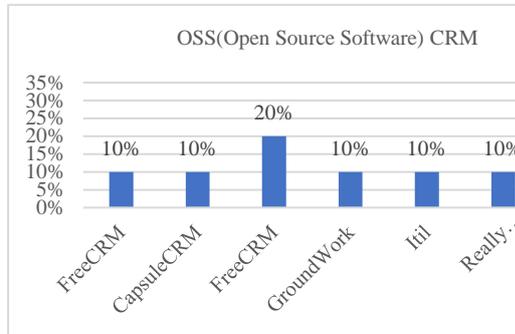


Fig. 5. OSS products utilized for CRM

Availability of OSS components for free gives developer space to incorporate OSS in their commercial product [XXX]. More than 50% of commercial software packages incorporate OSS components. Banking sector is resistant of using complete OSS product because of regulation and enhanced compliance oversight and the inherent associated risks. Approximately 13% of respondents use commercial core banking software T24 (TEMENOS) and fidelity information systems in their respective bank as shown in figure 6. Daily human resources tasks for management and planning are completed via HR software which is a digital solution. HR PeopleSoft is utilized the most.

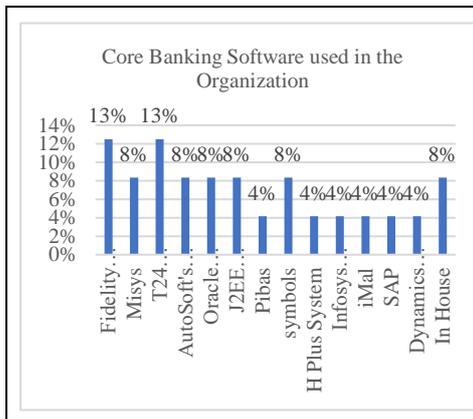


Fig. 6. Commerical Core Banking Software

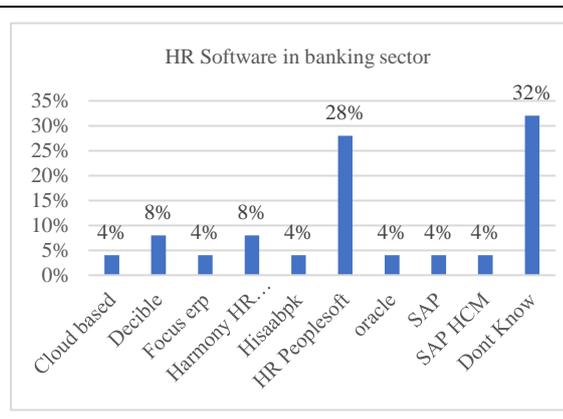


Fig. 7. Commerical HR Software used in bank

Information technology has played an important role in modern era. In developing countries like Pakistan the healthcare systems are extremely important [XXII]. The majority of the healthcare industry in developing countries is working at

very deprived level [XXVI]. It appears that Pakistan is lagging behind in healthcare service facility, there is nearly nonexistent of Healthcare Information System (HIS) [XVIII] [I]. These reasons enforce us to improve the current healthcare system with latest technology. For proper healthcare system development and implementation Health Level 7 (HL7) standard must need be incorporates in order to exchange data among worldwide healthcare computing applications [XII].

When participants are queried about the OSS information system utilization 62.6% of them claims that they are not using closed source software with maintenance contract. Rest of them accepts their dependency.

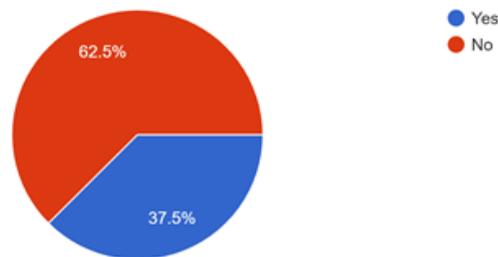


Fig. 8. IT system developed by contract from an outside supplier

In case of universities the Virtual Learning System (VLE) is vital specially in these current scenarios. When participants are questioned about the Open source VLE being used majority claims that they use Moodle (55.6%) after customization.

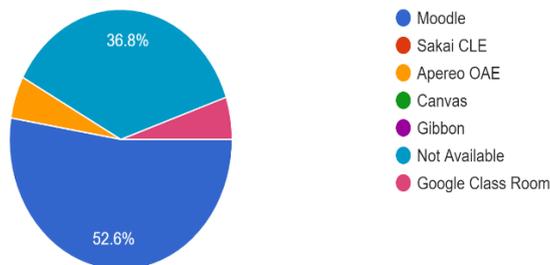


Fig. 9. OSS VLE Software

For Open source Lecture Capture/Podcasting software 27.8 claims that they use Cam Studio. In case of CSS majority respondents use their mobile phone (32%). For Open source Online Lectures/Webinars/Remote Participation software utilization respondents claims that there is no availability. Only 10.5 claims that they use open meeting and Skype. In case of CSS 10.5 claims that they use Adobe connect and blackboard collaborates.

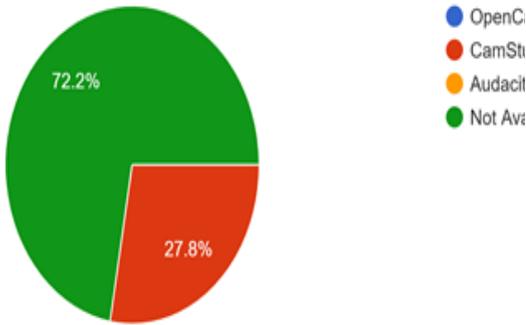


Fig. 10. OSS Lecture Capturing software

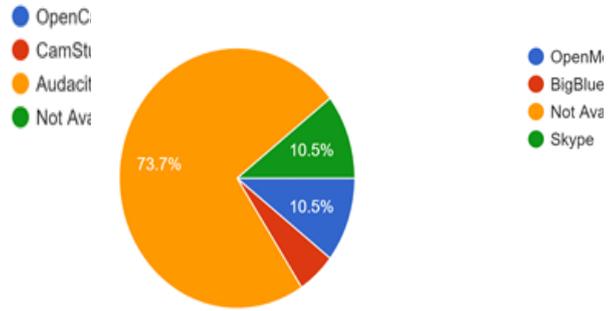


Fig. 11. CSS Online Lectures Participation software

Knowledge and Awareness of FOSS

Out of 110 participants, 74(73.6%) were agreed that open source is important because it is available for free without cost. 63(59.4%) participants agreed that access to the programs source code is significant. 64(60%) participants agreed that access to the programs source code modification is substantial. In the case of redistribute the modified software code 47(44.3%) participant agreed on that. When asked about OSS license unreasonable restrictions 32(30.2%) claims that there is no need to impose license unreasonable restrictions as depicted in figure 12.

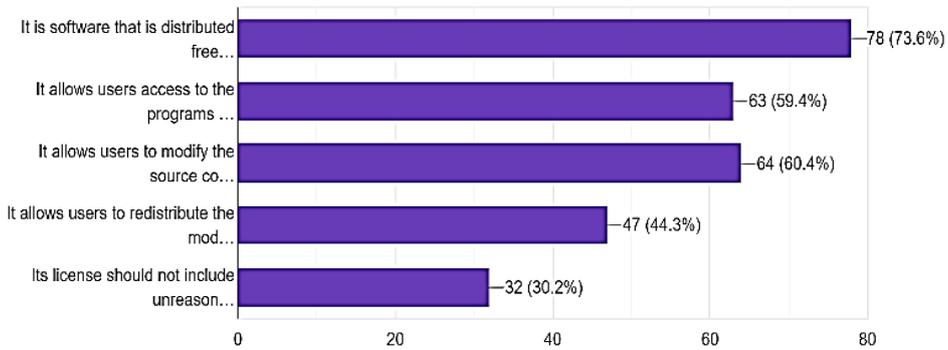


Fig. 12. OSS Knowledge and Awareness

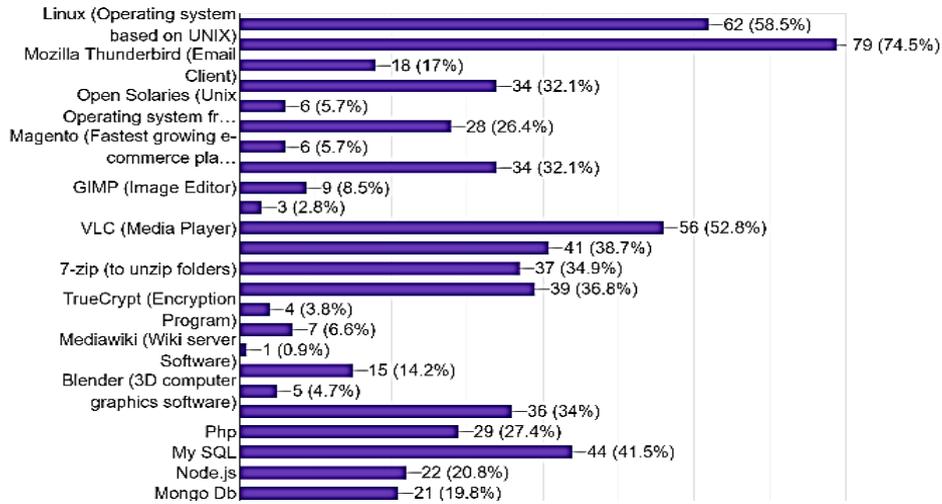


Fig. 13. OSS Product usage

It has been noticed that people are well aware of OSS Application software as well as Operating system. In case of application software 79(74.5%) participants utilize Mozilla Fire Fox web browser, 36(34%) use apache HTTP web browser, 39(36.8%) practices PDF Creator, 29(27.4%) uses Php, 44(41.5%) utilize MySQL, 34(32.1%) uses Open Office and File Zila, 37(34.9%) utilize 7-zip , and 56(52.8) use VLC media player respectively. In operating system case, 62(58.5%) use Linux operating system. Shown in figure 13.

Technological Factors

Technological context plays a critical part in the dissemination of OSS into corporate environment. The technological context deals with the technological characteristics held by the organization and the impact of the adoption. There are certain technological factors that influence the decision process specially in case of mission critical software. Several significant factors relating to the technological context includes quality, security and technological benefits of OSS.

Quality

In mission critical sector available Open source product quality plays an important role in adoption. Trustworthiness in OSS products are positively impacted by several factors includes Product quality, which is a significant factor which includes reliability interoperability, paucity of software features, benchmark studies, mature community and others.

The reliability of software requires the absence of defects which effects operation, data loss or sudden failures [III]. Interoperability is highly desired in a critical sector such as healthcare. OSS recommended open standards and protocols so that multiple parties can integrate their work easily. Open standards code has internal and external advantages. Internally, it provides flexibility in changing the system and customizing it with the free and unrestricted access to the code. Externally, open source systems tend to comply with open architectures and standard programming interfaces like in

the medical context Health Level 7 (HL7) protocol [III], [XV], [X], [VIII]. The mission-critical application can't incorporate untried and untested code. For mission-critical software, established open source projects are needed to be reliable enough in which the developer handle bugs easily, demonstrate the ability by making releases and also provide support [XIV]. Benchmarking is the way of measuring and comparing usability metrics of business to industry bests and best practices from other companies [III], [XV]. Mature OSS product developer's community is more responsive. It has been observed in different case studies that the developer respond immediately with workaround suggestions, diagnosed the problem, corrected the issue and release a corrected version within a day whereas in CSS the problem reported will be taken care in the next release which is 10 months away [XIV]. High numbers of fork products (proliferation of interfaces) place a negative impact on the adoption. The main advantage achieved by forking is that if the original developer does not want to continue then there is a possibility that the other group can continue his work and serve the customers already using the software.

The Major obstacle of OSS usage is that there is no centralized support because of open ownership. Open ownership means the software is not owned by a software provider who can provide support and training. The firm must need support from other sources like third-party support, re-train IT staff and community. Some of the OSS products are not properly/comprehensively documented. OSS product documentation in contrast with the commercial product is sometimes not on standard and up to date which creates a barrier for OSS adoption, especially in enterprise culture. The documentation quality varies from product to product [XXVIII], [XV], [IX], [XVI]. Figure 14 shows the respondent's perspective regarding OSS quality factors. Having lack of adequate documentation is found to be very important for 41% and important for 31% of respondents. Product support is found to be very crucial for 41% and important for 34%. Proliferation of interface and product characteristics is very important for 31% and 42% of expert's surveyors respectively.

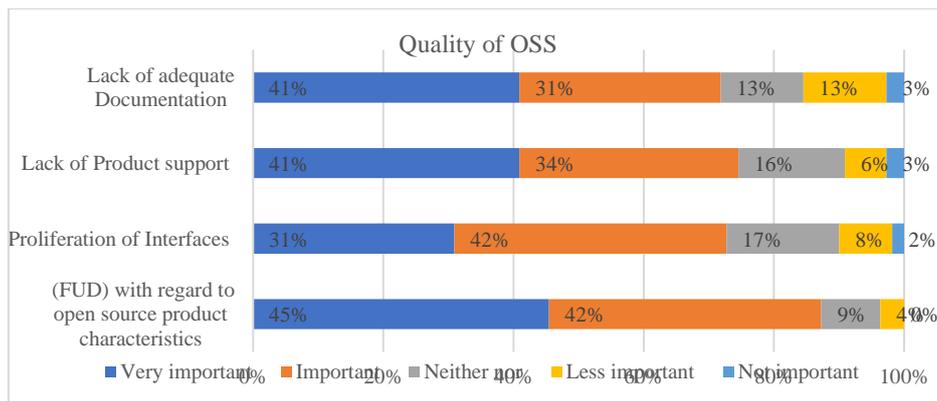


Fig. 14. OSS Quality Factor

Security

Security related risk is very important for an organization in critical sectors to adopt OSS. There has been a debate that having source code will compromise the security of OSS. Accessibility of source code has some positive and negative impacts. Having source code will enable user/developer to find and fix the loop hole in the software with in less time as compare to CSS. When there is a need for patches than they are available within hours instead of days and months [XV] [XXIII].

As the source code is available therefore there is a chance that malicious people can inject possibly dangerous programs or bugs in the organization system. OSS products need to be checked and validated before utilizing or become part of an organization ecosystem especially related to critical sector whether the project is single, medium or complex. To avoid the malicious behavior of OSS product thoroughly checking and validation of OSS products/components must be done [XIX], [XI], [XX].

Data migration is one of the biggest challenges to OSS adoption in critical sector and it take initial higher cost [XV]. The management needs to consider an adequate data conversion path while migrating from CSS to OSS. Three ways can be used for migration i.e. big bang (migration with in few days while closing the organization operations), group transition (section by section transition), user transition (targeting individual user). Data conversion is another major issue along with data migration. Proprietary vendors are reluctant to provide necessary details required and charged the user for data conversion. Compatibility and integrity issues for data conversion is a major risk associated with data migration[XV], [IX], [XXIII], [XXI], [XXIX]. Figure 15 depict the security factor importance. OSS product needs to be verified and validated before usage approximately 57% respondents are highly agreed and 33 % agreed. Data migration and integrity matters a lot to approximately 46% IT experts and 42% agrees on that.

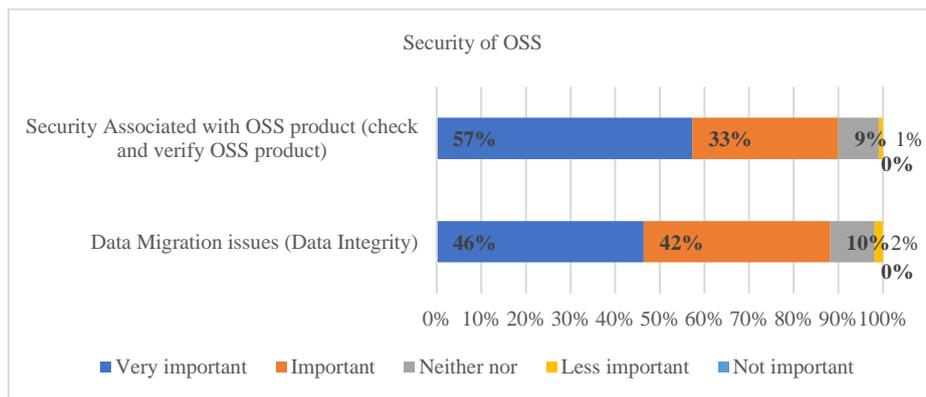


Fig. 15. OSS Security Factors

Technological Benefits

The most important OSS adopting considerations is the potential technical benefits. Mission critical sector organizations have technical benefits of open source software adoption that lend it particularly well to their needs. Besides the low costs, access to source code and access to development community, Open source software provides flexibility by eliminating platform and vendor lock-in because Open standards give users, flexibility and freedom to change between different software packages, platforms and vendors and thus to improving interoperability. By using OSS critical organization can reduce dependency on a single vendor or platform. Compatibility, interoperability and integration are one of the major OSS adoption challenges in critical sector which need to be carefully analyzed and for wider adoption high compatibility is required [XV] [X]

Mission critical sector organizations are aware of the pitfalls of open source software technology but they are comfortable in taking the risk. Mission critical sector organizations are not worry about the OSS product complexity, OSS ecosystem complexity, lack of road map and OSS license complexity. There is uncertainty in OSS projects as in past research it has been revealed that approx. 17% of all projects have been successful and approx. 46% of project were abandoned in the initiation stage which leads to lack of roadmap and OSS ecosystem complexity [XIX] [II]. Figure 16 depict the technological importance. .32 % of respondents have strong opinion that OSS has drawbacks associated with them and 45% thinks that the benefits outweigh the disadvantages of OSS.

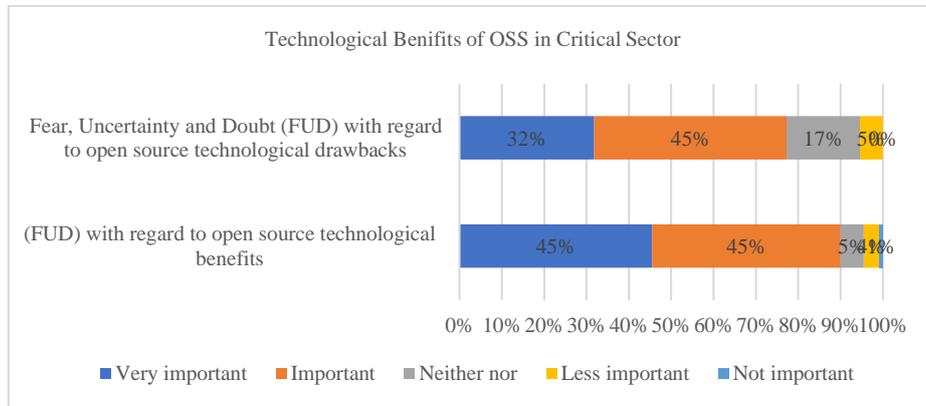


Fig. 16. OSS Technological benefits

Intrinsic Factors

Intrinsic factors comprise of resources, structure and processes which are required for provision in innovation and adoption. Intrinsic factors are identified as the factors that emphasize on the needs of an organization for being adequate for OSS adoption. There are certain organizational factors that influence the decision process specially in case of mission critical software. it includes the organizational internal affairs like top management support for adoption, availability of OSS literate IT staff and greater saving possible by using OSS, vendor association and OSS alternative availability etc.

Business Strategy for OSS Adoption

All factors under business strategy category are found to be significant. In organizational environment 78% respondents agree that lack of knowledge / experience and 74% agrees that awareness regarding OSS has negative impact on adoption approximately 78% respondents agree on that. There are organizations or corporations that utilized cracked closed source software, therefore, it is hard to convince them to use open source software. The lack of support from senior executives (habit of using unlicensed software and having conservative nature) is a major barrier that hinders the migration process approximately 72% respondents agree on that.

One of the major OSS adoption risks is lack of reliable information regarding the mission critical software product availability and service provider reliability, approximately 73% and 69% respondent's claims respectively. 67% It experts claims that in critical Infrastructure the key legal concerns for organizations adoption of mission critical software was OSS licensing and others regulation /policies which had a negative impact on OSS adoption. 76 % respondents claim that Organizational readiness has a great impact on OSS adoption in mission critical IT infrastructure. Organizational readiness includes subgroups like lack of financial and human resources, organizational structure and size of the Organization. Small organizations may lack the skilled staff and fully equipped IT department which can hinder in proper OSS implementation and integration while large organizations have more probability to successfully implement OSS adoption. Having an active political support in the organization increases the probability of OSS adoption, 59 % respondents accept that. Hidden power structures and organizational politics play a critical role in directing how OSS would be used before we get to the technology and other aspects of OSS adoption Procurement criteria are important for OSS adoption in critical sectors because it is influenced by institutional requirements and by CEO personal preferences, 65% respondents agree on that. CEO Conservative nature (attitude and practice reliability) relies only on established and commonly used products because they trust on their current procurement criteria. Large Organizations that belong to critical sectors and that have experience of more than 5 years definitely make their IT infrastructure stable and complex and it's hard for a company to adopt OSS easily 79% respondents approve that as depicted in figure 17.

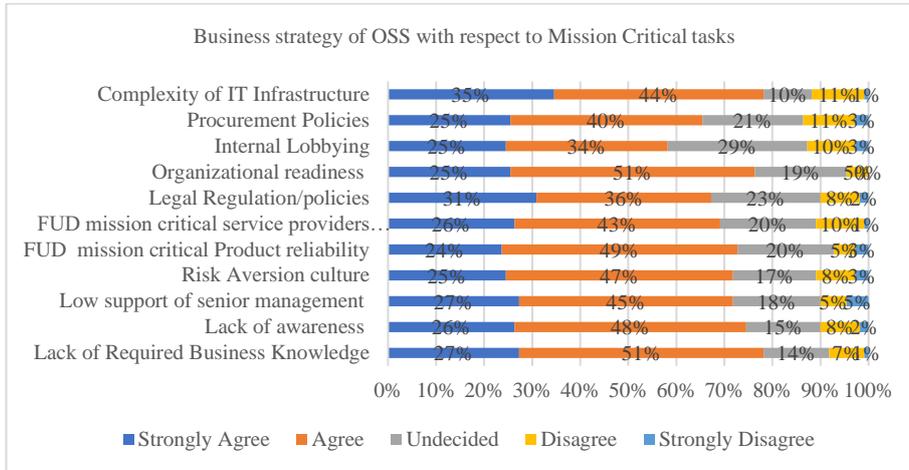


Fig. 17. Business Strategy of OSS Adoption in critical IT Infrastructure Industry

Non-Technical aspects of OSS Adoption

Open source software associates some cost which the top management need to know such as hardware cost, administration cost, purchasing (in case of acquiring a commercial product of OSS), maintenance, upgrade cost, transition, end-user operation cost, sunk cost and others. OSS brings clear advantages for enterprises, such as low total cost of ownership (TCO), 71% respondents accept that. Although OSS is considered as free but organization may need to hire OSS specialists to provide help to their staff for proper implementation and execution. Indirect cost is not a particularly significant risk factor for large organization whereas medium size organization represents a risk factor which needs to analyze carefully. Fig 18 depicts the survey results which clearly show that adoption cost has profound impact on OSS adoption in critical sector, 79% IT experts agrees on that. Approximately 74% respondents agree on that many critical IT infrastructure companies already have proprietary solution implemented before OSS emergence therefore employees are resistant to go for change. Organization with centralize authority can force their employee to adopt new technology whereas decentralize authority organization can face problems. There are some situation where the proprietary software vendor have good communication as well as personal relationship with the top management because of which the organization is resistant to adoption[IV] [XXIII] [IX].

As there is a lack of marketing and sales organizations which can promote OSS therefore unreliable, unclear and incomplete information regarding OSS projects and less availability of commercial open source vendors hesitate mission critical firms to adopt OSS even in earlier stage [XXVII], 73% respondents agrees on that. Approximately 73% respondents believe that there are some areas where open source software alternative is not available. In mission critical software there is a limited availability of software with required functional need. Therefore, the organization need to develop a new OSS or customize the available one [IX] [XXV]. Firms that are unsatisfied with the existing technology are more likely to adopt new innovations. The organizations in which performance of the existing system are not according to their requirement and expectations, search for new technology solutions.

Approximately 78 % agrees that low level of satisfaction with existing commercial systems in critical IT Infrastructure provides a motivation to adopt OSS. All non-technical aspects are depicted in figure 18.

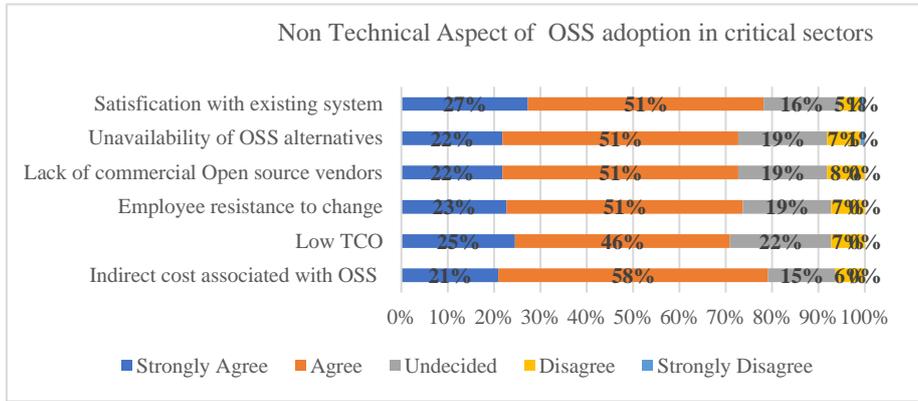


Fig. 18. Non-Technical Aspect of OSS adoption in critical sectors

Extrinsic Factors

Environment context plays a critical part in the dissemination of OSS into corporate environment. The Environment context deals with the consideration of competitors, providers, the government influence on adoption and the organization operational setting and context. Environment context can be categorized in terms of economic and country differences like policies, law, industry structure, cultural matters and public discourse nature. Environment factors influences the decision process specially in case of mission critical software. It has been clear from figure significant amount of respondent agrees on the external issues for OSS Adoption.

Approximately 80% respondents agree that Governments place different policies that create issues for OSS adoption in organizations. Lack of government support limit OSS market penetration and discourage organizational adoption of OSS specially in critical sectors organizations [XXVII], [XXXI]. Approximately 61% II experts accept this fact that hidden power, public and political pressure plays a crucial impact on OSS adoption [XXVII]. It has been observed that the cost of finding appropriately trained personnel for proprietary applications are lower than for OSS, also it has been observed in a survey that approximately 74% of firms that are specialized in OSS face difficulties in hiring qualified workforce in their organizations. Lack of OSS qualified workforce in market and external service providers is a barrier in the OSS adoption because if an organization lacks support staff then there is no one to facilitate them

[XXVII], 79 % accepted this fact .that lack of awareness is a critical barrier in OSS adoption. Some of the biggest obstacles associated with OSS is that there is no centralized marketing authority for OSS [V]. Many organizations do not follow the Industry-wide standards for IT which will enhance the chances of OSS adoption. Approximately 79% and 82 % experts agree on this as shown in figure 19.A country

cultural, economic and technological differences play an important role in critical organizations OSS adoption. The company that is established in a country with the high level of development declines OSS adoption whereas companies that are in a country where the distance between power and the people is high also avoid OSS adoption [XXIII], 72 % respondents agrees on this.

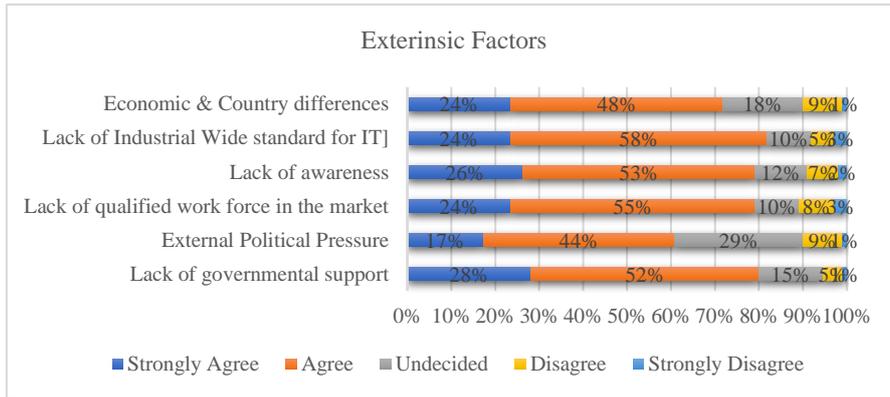


Fig. 19. External aspects of OSS Adoption in Critical Sector.

General Use of FOSS

In this section the respondent needs to rate different factors with respect to their importance on a linear scale from 1 to 5 (strongly agree to strongly disagree). It has been observed that all participants are strongly agreed on the general usage of OSS factors refer figure 20. Participants agreed (60.6%) that they think of switching toward OSS because of some successful implementation seen in market. Shown in figure 21.

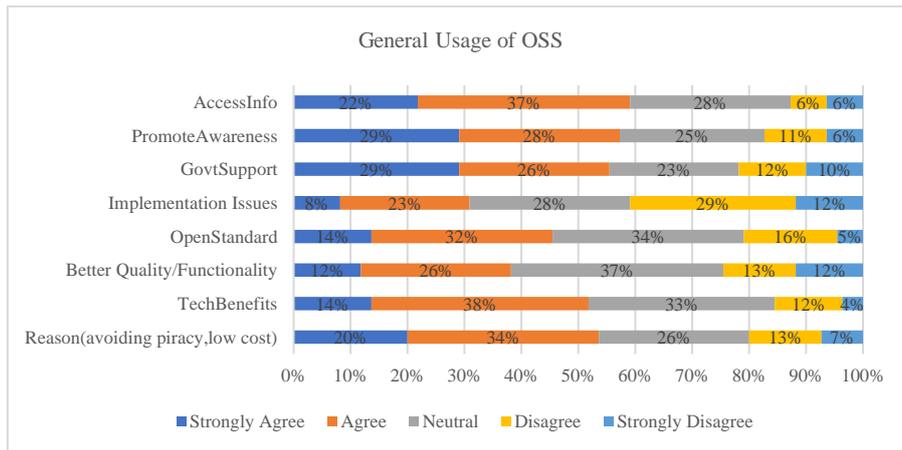


Fig. 20. General Usage of OSS Adoption in Critical Sector.

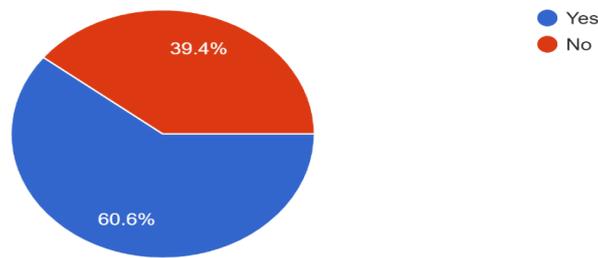


Fig. 21. Successful OSS implementation in industry

IV. Conclusion

This paper aims to clearly identify factors that serve as a barrier to OSS adoption in critical IT industry so that the adoption rate of OSS in critical IT infrastructure increases with full trust.

It has been observed that compatibility, skilled staff and maintenance/support are main barriers in proper adoption of OSS at certain times and these problems will get diminishing with the passage of time because people are now becoming aware of the benefits of OSS and there are many companies who are willing to migrate towards OSS.

This paper describes more specifically the key barriers in terms of quality, security, technological benefits, top management support, adoption cost, vendor association, availability of OSS alternatives, and external support that hinders the OSS adoption in critical sectors.

V. Future Work

In future theoretical framework of open source software adoption in critical IT Infrastructure Industry will be proposed that utilizes the organizing logic of the Technology, Organization, and Environment (TOE) framework. The propose framework will help in taking decision of OSS adoption. Furthermore, a production level analysis of the proposed OSS adoption framework is needed to validate the theoretical framework.

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