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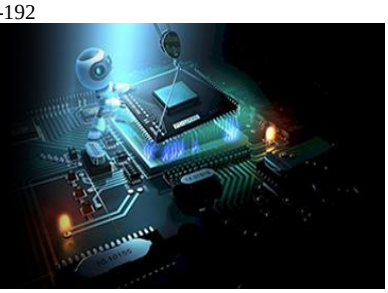

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Trust in open-source software communities: A multi-dimensional analysis

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Abstract
In recent years, Open-Source Software (OSS) has emerged as a dynamic and innovative field. It is driven by a community-based software development paradigm, which differs from typical, centralized software engineering approaches. Members of the open-source community cooperate and contribute jointly throughout the project's lifecycle, establishing an environment of openness, transparency, and mutual support. The open-source software development team is widely dispersed, with little face-to-face interaction or conventional organizational structures. As a result, building and sustaining trust among contributors is critical to effective collaboration, coordination, and project sustainability. This article investigates how several trust characteristics, such as reputation, knowledge, historical contributions, and communication transparency, influence interpersonal and collective trust in OSS communities. The Linux Kernel Community, a well-known and successful open-source project, is used to examine the dynamics of trust. This study attempts to provide insights into increasing collaborative efforts in distributed software environments, specifically within OSS communities, by identifying the main aspects that foster or undermine trust.

Keywords: Open-source software, OSS community, developers, trust, trust factors

1. Introduction
Open Source Software[OSS] is defined as a software system that is free to use, and code is fully accessible to anyone and gives users privileges to modify the existing data [1]. Presently, OSS is more reliable and popular because it facilitates the users with quality of solutions, ability to customize fix and competitive features and technical capabilities [15]. It is a collaborative effort where programmers improve upon the source code and share the changes within the community. Developers from different areas worldwide collaborate to develop software in the virtual community, called the open-source community. All the members of the OSS community interact and support each other. For example, the success of the OSS project generally depends on the community of the developers because OSS systems initiate with a developer who solves their specific problem and solution share within a community [2]. OSS Community always builds trust based on community members as they share ideas and goal about the projects. A new community member is always considered a less trusted member because they need to show the willingness and positive contribution before being counted in the community. Joining an existing open source community, initially there is no control and no rules on governing members joining an existing open source community [1].

2. OSS Community Structure
Unlike the traditional systems, the OSS Community structure doesn't have to restrict formal layout, and the projects plans schedules [4]. But on the other hand layout of the community is not entirely sorted. The work schedule is basically designed based on the skills and personal interests of the community members. Furthermore, the participants' roles are changed roles are changed with the passage of time [5]. Open source communities are self-governing and self-organizing the highly organized model in the OSS community is "ONION MODEL", which shows the functions assigned to the community members [4].
The Project leaders play the role as a Core Developers, are responsible for guiding and coordinating the development of an open-source project. The contribution of these developers is an extended period.

Each Open source community has a unique structure depending upon the nature of the system and its member population [5]. The contribution of the community members in the projects are uneven and most members are passive users, and most systems are developed by a small number of developers [4].

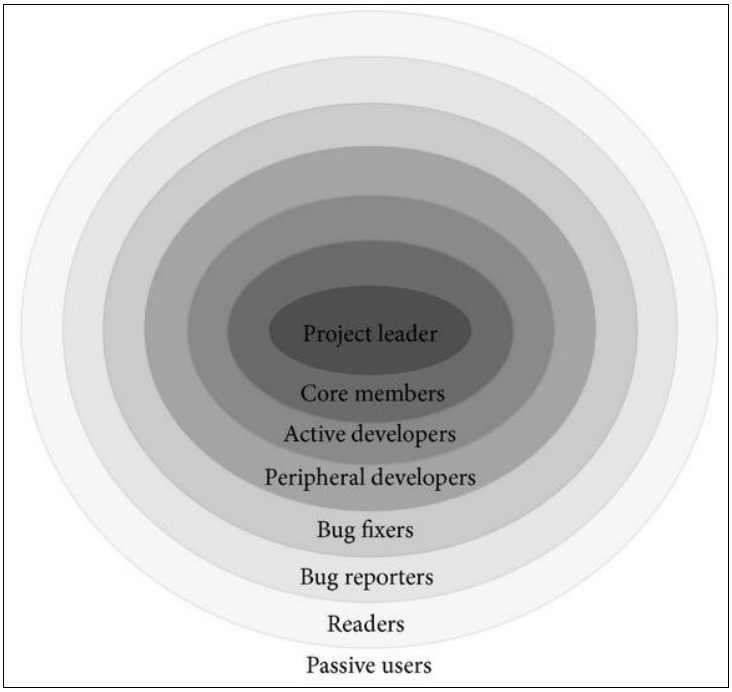

Fig 1: Structure of OSS community [4]

Roles	Purpose
Project Leader	Who leads the project and gives the direction to the project.
Core Developers	Leading the project in the long term and highly recommended in OSS Community
Contributing Developers	Contributor Developers are also known as peripheral developers, occasionally contribute to projects and have a limited role in OSS Community.
Bug Reporters	Find the Bugs and report it
Bug Fixer	Bug Fixer fix the bug that is either discovered by themselves or reported by Big reporters
Readers	Readers are active users of the system; they use the system and try to understand how the system works by reading the source code.
Passive Users	They are just using open-source software but don't contribute as developers and active users

Due to the growing phase 65% of companies used open-source software during the development of the projects. In another study was found that 41% of small organizations have used an open-source strategy [15].

1. Trust

Trust forms a pillar for effective cooperation, which leads to a reduction in conflicts and risks, associated with quality software development [7]. There is a trust equation which helps to understand the meaning of trust more closely.

A. Trust Equation [13].

Trust equation is all about the trustworthiness, is equal to the credibility, reliability, intimacy and self-orientation. They are closely combined with trust equation [13].

Fig 2: Trust Equation [13]

- **Credibility:** it refers to the words actually we speak.
- **Reliability** It refers to the actions and someone to honors their commitments.
- **Intimacy:** it refers to the safety and security that feel when entrusting someone with something.
- **Self-Orientation:** Self-orientation refers to the focus of the person in question, and how much we align to the interests of others [13].

2. Trust model

Trust is based on the perception or points of view of the trustor and it's always hold interpersonal relationship between the two persons. In 1995 Mayer proposed three essential characteristics of trust [14].

- **Ability:** Ability refers to the competence and technical expertise of an individual to perform specific tasks effectively. In open-source software (OSS) communities, it implies that a contributor has the required knowledge, skills, and experience to make valuable contributions whether in coding, debugging, documentation, or design. Trust is built when community members consistently demonstrate their abilities through quality work, which in turn fosters collaboration and respect among peers [14].
- **Benevolence:** Benevolence means having a sincere concern for the well-being of others and a willingness

to support fellow community members. It reflects a spirit of helpfulness, open communication, and mentorship. In OSS, benevolent contributors assist others by answering questions, reviewing code constructively, and encouraging participation. Such behavior enhances the collaborative nature of the community and increases mutual trust, even among geographically distributed and culturally diverse members [14].

- **Integrity:** Integrity refers to the honesty, fairness, and ethical standards upheld by a person. In OSS communities, integrity is demonstrated when contributors adhere to project guidelines, give proper credit, and maintain transparency in their actions. Individuals who act consistently with the community's shared values and goals—without seeking unfair advantage or recognition—are seen as trustworthy. This reliability strengthens the social fabric of the OSS project and encourages more contributors to engage confidently [14].

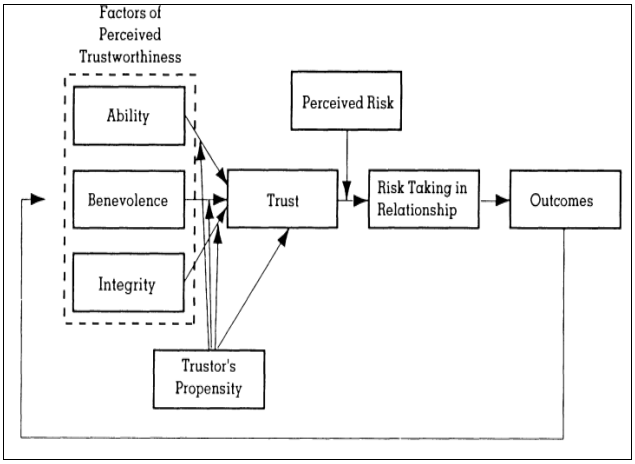

Fig 3: The model of trust [14]

3. Trust in open-source community

Trust is a German word derived from the word "TROST"; it means comfort [7]. Trust is the relationship between people taking a risk to accept another person's action. Goldbeck (2013) defines trust as *"A person trusts another if she is willing to take a risk based on her expectation that the trusted person's actions will be lead to the outcome"* [2]. *Grandison and Sloman (2000) defined "trust as the firm belief in the competence of an entity to act dependably, securely, and reliably within a specified context*" [8]. These Definitions are clearly defined in the open-source community because trust is based on the willingness of the job or task by them. An action also plays a prominent role which completes when it meets the expectations. Gosain(2006) defines "trust as the extent to which a person is confident in, and willing to act on the basis of the words actions, and decisions of the other" [2]. The basic components of trust which are used in OSS communities.".

Table 2: Components of Trust [7]

Components	Description
Trust	the belief that somebody is good and honest
Trustor	Ones create trust by providing some benefits to the beneficiary
Trustee	Who is trusted
Trusted	Deserving Trust

4. The role of trust in open-source communities

Trust plays a prominent role in open-source communities because trust is directly linked to secure a functional development community, community governance, and on-going work [8]. Higher trust values existing among community members encourage new members to join the community. As membership in the community increases, team performance increases [7]. It cores important to note that trust in OSS communities is rather institutional than personal. The numbers of participants to a given open-source project are often very large and the communities are open to existing and new entries. Thus the development of trust cannot be based on repeated interactions of the same individuals who get to know each other over time and learn to trust each other [9]. The OSS communities have a quick form of trust which is called "Swift Trust" [7]. Swift trust describes a form of trust that is found in terms that only work together for a limited period of time and do not have the opportunity to develop trust based on personal relationships and mutual control. Members of such temporary teams decide on how much they can trust the others even before actually joining the team [9]. The first type of swift trust exists in situations where the second person not to deceive the first needs second. It is in the interest of the second person not to deceive the first one. Such a type of trust is based on the self-interest of the first party [7]. On the other side trust is a critical factor for enabling effective online collaboration in open source software(OSS) project teams [10]. In OSS communities trust is generally considered as two types' local trust and global trust. Local trust value is the personalized score between two members in a trusted network. This means that how member A should trust B. On the other hand, the Global trust value is the aggregate score computed over the network and is visible by all members of the given network [10].

5. Trust Factors

The factors that influence the adoption of open source software may differ from the factors that induce trust [11].The research done by Del Bianco et.al (2011) provides a list of factors that are believed to affect trustworthiness the most according to its interviewees [11]. Every trust factor has its own importance in the OSS community. Some Trust factors are least significant and other play a prominent role in the OSS Community. There are some trusts factors [8, 12].

- Reliability
- Alignment with software
- Interoperability
- Maintainability
- Standard Compliance
- Performance
- Usability
- Security
- Portability
- Reusability
- Modularity
- Familiarity
- Possibility to influence
- Culture and values
- Sharing information
- Common Goals
- Reputation
- Practices and skills

Every trust factor has its own importance but "Reliability" and "Alignment with software' highly significant trust factor [8].

6. Factors affecting trust in OSS community

Trust plays a pivotal role in fostering effective online collaboration within open-source software (OSS) project teams. When trust is present among OSS contributors, individuals are more inclined to collaborate openly, share knowledge freely, and accept contributions from others without hesitation [10]. The decentralized and voluntary nature of OSS development underscores the importance of interpersonal and community-level trust to sustain active participation and high-quality output.To explore the factors influencing trust within OSS communities, a survey was conducted focusing on the Linux Kernel Community, one of the largest and most active OSS projects globally. The study aimed to identify which elements contribute most significantly to building trust among contributors. Interestingly, the findings revealed that 'familiarity', 'possibility to influence', 'the culture', and 'values' were among the least prominent factors perceived to influence trust in this context. This suggests that while these dimensions may contribute to trust in general organizational settings, their impact may be less significant in highly technical and meritocratic communities like Linux Kernel development [12].

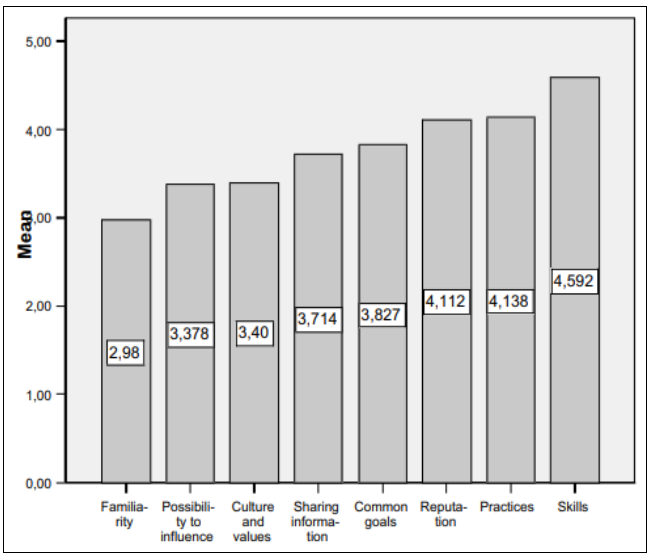

Fig 2: The means of the factors of trust [12]

According to the survey, skills, practices, and reputation have an essential role in trust towards the Linux Kernel Community, and the rest of the factors play their part on a medium scale [12].

7. Conclusion

At this juncture, Open-Source Software is a general research area. Due to its growing phase, many companies use open-source software during the project's development. Therefore, open-Source software is one of the major research areas in which members of the development team have to trust each other. This paper discussed the adoption of various trust factors and analysed each according to the rank, reliability, and alignment with software ranked high for building trust. This study also clarifies the role of faith in one type of OSS Community. According to the analysis of the Linux Kernel community, there are eight factors; the minor significant factors are familiarity, the possibility to influence, culture, and values. The Kernel Linux community is extensive, and people are not very familiar with each other. Therefore, familiarity cannot be ranked high like most open-source projects. Maybe people willing to gain much influence do not join this kind of community. The present analysis represents an opening for further studies concerning the role of trust in different sorts of OSS communities.

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