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Cloud shield: Backing honor based trust authority for cloud utility

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Abstract:

Trust management of cloud services is emerging as an important research issue in recent years, which possess significant challenges because of mostly dynamic, distributed, and translucent nature of cloud services. In this project we describe Cloud Armor, a platform for credibility based trust management of cloud services. This platform provides a crawler for automatic cloud services discovery, a modifiable and strong credibility model for measuring the credibility of feed backs, and a trust-based recommender to recommend the most trustworthy cloud services to users. This project presents the motivation, design, implementation of the system, and a demonstration of the Cloud Armor platform.

A reputation based trust management frame work, Cloud Armor provides a set of functionalities to deliver Trust as a Service (TaaS), which includes a plan to show the credibility of trust feed backs and maintain the user privacy and an availability model to manage the availability of the decentralized execution of the TMS. The benefits of this model are provided to a prototype and experimental studies were made using a group of real world trust feed backs on cloud services.

Index Terms: Cloud computing, trust management, reputation, credibility, credentials, security, privacy, availability

Introduction:

A cloud service with mostly dynamic, distributed and translucent nature makes the TMS a very big challenge. Most Berkeley researchers ranked the trust, security and availability as one of the top 10 problems for adopting the cloud computation. Mean while, only Service Level Agreements (SLA's) are not sufficient for establishing the trust between the cloud consumers and providers.

A feedback from consumers' is a very good source for accessing the overall trust worthiness of cloud services. Many researchers understood the importance of trust management and gave different solutions for assessing and managing the trust based

on the feedbacks which were collected from many participants. This project mainly focuses on how to improve the trust management in cloud environments by giving the planned ways for ensuring the credibility of the trust feedbacks. Mainly, we discuss the following issues in cloud computing environment for the trust based management system:

Consumers' privacy: The privacy concerns are raised by the adoption of cloud computing. Consumers will be having the communication with the providers, which can involve much of sensitive information like date of birth, address etc. or the interest of one consumer can be leaked to other consumers. Hence, the services must preserve the consumers' privacy where the interaction is involved.

Cloud services protection: Cloud services, very commonly, experience the attacks from its users. Attackers can misuse the cloud service by creating many accounts and giving the feedbacks in a negative way (Sybil and Collusion attacks).

Absolutely, these users should be detected and cancel their accounts. This involves very big challenges to the cloud providers. And moreover, the user can have several accounts in the same cloud service. Hence this is somewhat difficult for the providers to detect the malicious users and hence to eradicate the problems of Sybil and collusion attacks.

Trust Management Service's Availability: For effective trust management, the TMS system will be acting as an interface between the user and cloud services. Then providing guarantee for the availability of the TMS system is a very tough problem to be encountered by the service providers due to the large number of consumers using the same cloud service and due to the dynamic behavior of the cloud services environment. Hence, the TMS should be very much adaptable and highly dynamic for the changes in the cloud environments.

This project deals with the design and implementation of Cloud Armor, which means Cloud consumers credibility assessment and trust management of cloud services. This is nothing but a framework for the reputation based trust management system in the cloud services environment. Here the trust is delivered as a service (TaaS) where TMS will span many different distributed nodes to manage the feedbacks in a scattered way. Cloud armor accomplished several techniques to describe the credible feedbacks different from the petty ones. In short, the Cloud Armor has some salient features as follows:

Zero-Knowledge Credibility Proof Protocol (ZKCP2): The Cloud armor has introduced the zkcp2 technique, which not only protects the consumers' privacy but also will make the TMS to recognize the credulous feedbacks of the consumers from the petty ones. This project has introduced the Identity Management service (IdM) which will help the TMS in calculating the credibility of the trust feedbacks of the consumers without breaking the privacy of the consumer. This introduced some anonymization techniques which will maintain the users' privacy in the identity and interactions of the users with the providers.

Credibility Model: The credibility of feedbacks of the users or consumers will play a crucial role in the performance of TMS service. Hence it provides some metrics or techniques for the feedback collusion

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detection which will include the Feedback Density and Occasional Feedback Collusion, which will differentiate the feedbacks of petty users from the credibility feedbacks. This will also have the ability to detect the strategic and occasional behaviors of collusion attacks. Besides all these, we introduce some other metrics for the detection of Sybil attacks, which will include the Multi-Identity Recognition and the Occasional Sybil Attacks. These metrics will allow the TMS to identify misleading feedbacks from the Sybil attacks.

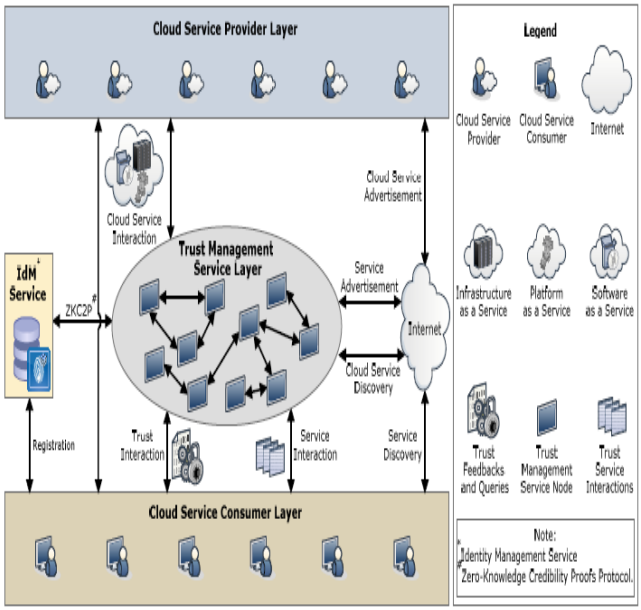
An Availability Model:

High availability is an important requirement to the trust management service. Thus, we propose to spread several distributed nodes to manage feedbacks given by users in a decentralized way. Load balancing techniques are exploited to share the workload, thereby always maintaining a desired availability level. The number of TMS nodes is determined through an operational power metric. Replication techniques are exploited to minimize the impact of crashing TMS instances. The number of replicas for each node is determined through a replication determination metric that we introduce. This metric exploits particle filtering techniques to precisely predict the availability of each node.

2 THE CLOUDARMOR FRAMEWORK:

The CloudArmor framework is primarily based on the provider orientated structure (SOA), which delivers accept as true with as a provider. SOA and net offerings are one of the maximum essential allowing technologies for cloud computing in the feel that assets (e.g., infrastructures, structures, and software) are uncovered in clouds as services. specially, the agree with management carrier spans numerous disbursed nodes that divulge interfaces so that customers can give their feedbacks or inquire the believe results. figure 1 depicts the framework, which includes three special layers, namely the Cloud provider company Layer, the agree with control carrier Layer, and the Cloud service customer Layer.

The Cloud provider company Layer: this layer consists of different cloud provider carriers who offer one or numerous cloud services, i.e., IaaS (Infrastructure as a carrier), PaaS (Platform as a carrier), and SaaS (software as a service), publicly on the net (more information about cloud offerings fashions and designs can be located). These cloud offerings are on hand via web portals and listed on net search engines such as Google, Yahoo, and Baidu. Interactions for this accretion are considered as cloud carrier interplay with customers and TMS, and cloud services advertisements where vendors are capable of put it on the market their offerings on the internet.



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The agreement with control provider Layer: this layer consists of numerous allotted TMS nodes which might be hosted in more than one cloud environments in special geographical regions. Those TMS nodes expose interfaces so that customers can deliver their remarks or inquire the accept as true with outcomes in a decentralized way. Interactions for this layer encompass: i) cloud service interaction with cloud service carriers, ii) carrier commercial to market it the trust as a provider to users thru the net, iii) cloud provider discovery via the net to permit customers to assess the accept as true with of new cloud offerings, and iv) zero-knowledge Credibility proof Protocol (ZKC2P) interactions allowing TMS to show the credibility of a selected client's remarks (info in section three).

The Cloud carrier purchaser Layer: Subsequently, this residue consists of various customers who use cloud services. For instance, a new startup that has constrained investment can eat cloud services (e.g., website hosting their offerings in Amazon S3). Interactions for this deposit consist of: i) provider discovery where users are capable of find out new cloud offerings and other services thru the net, ii) agree with and provider interactions in which users are able to deliver their comments or retrieve then agree with outcomes of a particular cloud service, and iii) registration wherein users set up their identity thru registering their credentials in IdM before the usage of TMS.

Our framework also exploits an internet crawling technique for automatic cloud offerings discovery, where cloud offerings are mechanically observed on the internet and saved in a cloud services repository. Furthermore our framework consists of an identification management carrier (see figure 1) which is answerable for the registration in which users check in their credentials before the usage of TMS and proving the credibility of a specific patron's remarks thru ZKC2P.

3. Zero-Knowledge Credibility Proof Protocol (zkc2p):

Because there may be a robust relation between consider and identification as emphasised, we advocate to use the identity control carrier (IdM) helping TMS in measuring the credibility of a patron's feedback. However, processing the IdM facts can breach the privateness of users. One way to preserve privateness is to apply cryptographic encryption techniques. However, there may be no efficient way to procedure encrypted statistics. every other way is to use anonymization techniques to technique the IdM statistics with out breaching the privateness of customers. Definitely, there's a alternate-off between excessive anonymity and application. full anonymization way higher privacy, even as full utility consequences in no privateness protection (e.g., using a de-identity anonymization

method can nonetheless leak sensitive facts through linking attacks). therefore, we advise a zero-know-how Credibility evidence Protocol (ZKC2P) to permit TMS to procedure IdM's records (i.e., credentials) using the Multi-identity recognition aspect (see info in phase 4.2). In different words, TMS will show the customers' comments credibility without understanding the customers' credentials. TMS methods credentials without including the touchy information. as a substitute, anonymized information

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is used thru constant hashing (e.g., sha-256). The anonymization manner covers all the credentials' attributes besides the Timestamps characteristic.

Identity management carrier (IdM): considering consider and identity are intently associated, as highlighted by David and Jaquet, we believe that IdM can facilitate TMS inside the detection of Sybil assaults in opposition to cloud offerings without breaching the privateness of customers. While customers try to use TMS for the primary time, TMS requires them to sign in their credentials on the believe identity registry in IdM to set up their identities. The trust identification registry stores an identity document represented by a tuple I = (C, Ca, Ti) for every user. C is the consumer's primary identity (e.g., person name). Ca represents a hard and fast of credentials' attributes (e.g., passwords, postal cope with, and IP address) and Ti represents the consumer's registration time in TMS. greater details on how IdM enables TMS in the detection of Sybil attacks can be found in segment four.2.

Agree with management service (TMS):

In a standard interplay of the popularity-based TMS, a

$$\mathcal{T}_r(s) = \frac{\sum_{c=1}^{|\mathcal{V}(s)|} \mathcal{F}(c,s) * \mathcal{C}_r(c,s,t_0,t)}{|\mathcal{V}(s)|} * (\chi * \mathcal{C}_t(s,t_0,t)) \quad (1)$$

user either offers remarks regarding the trust worthiness of a particular cloud provider or requests agree with evaluation of the service1.

assumptions and assault models:

On this paper, we assume that tms is treated by a relied on 1/3 birthday celebration. We additionally assume that tms communications are secure due to the fact securing communications isn't the point of interest of this paper. assaults along with man-in the- center (mitm) is consequently past the scope of this paintings. we recall the following varieties of assaults:

$$\mathcal{D}(s) = \frac{\mathcal{M}(s)}{|\mathcal{V}(s)| * \mathcal{L}(s)} \quad (2)$$

$$\mathcal{L}(s) = 1 + \left(\sum_{h \in \mathcal{V}(s)} \left(\sum_{c=1}^{|\mathcal{V}_c(c,s)|} \frac{\sum_{|\mathcal{V}_c(c,s)| > e_v(s)} |\mathcal{V}_c(c,s)|}{|\mathcal{V}(s)|} \right) \right) \quad (3)$$

• collusion attacks. Additionally referred to as collusive malicious remarks behaviors, such assaults arise while numerous vicious customers collaborate together to give several misleading feedbacks to growth the agreement with end result of cloud offerings (i.e., a self-promoting attack) or to lower the trust result of cloud services (i.e., a slandering attack). this form of malicious behavior can occur in a non-collusive manner in which a specific malicious user gives more than one deceptive feedbacks to behavior a self-selling attack or a slandering attack.

• sybil assaults. Such an assault arises whilst malicious customers exploit a couple of identities:

1. we expect a transaction-based feedback wherein all feedbacks are held in tms to provide severa misleading feedbacks (e.g., generating a big variety of transactions with the aid of developing multiple virtual machines for a brief length of time to depart fake feedbacks) for a self-selling or slandering attack. it is thrilling to notice that attackers can also use a couple

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of identities to conceal their negative historic believe facts (i.e., whitewashing attacks).

4. the credibility version: our proposed credibility model is designed for i) the remarks collusion detection inclusive of the remarks density and coffee comments collusion, and ii) the Sybil assaults detection which include the multi-identity recognition and low sybil attacks.

Remarks collusion detection:

Remarks density:

$$\mathcal{O}_f(s,t_0,t) = 1 - \left(\frac{\left(\int_{t_0}^{t} |\mathcal{V}(s,t)|\,\mathrm{d}t\right) - \left(\int_{t_0}^{t} \Delta_f(s,t)\mathrm{d}t\right)}{\int_{t_0}^{t} |\mathcal{V}(s,t)|\,\mathrm{d}t} \right)$$

$$where \Delta_f(s,t) = \begin{cases} \mathcal{C}\mu\left(|\mathcal{V}(s,t)|\right) & if\ |\mathcal{V}(s,t)| \geq \\ & \mathcal{C}\mu\left(|\mathcal{V}(s,t)|\right) \\ |\mathcal{V}(s,t)| & otherwise \end{cases} \quad (4)$$

Malicious users may provide severa fake feedbacks to control consider effects for cloud services (i.e., selfpromoting and slandering attacks). a few researchers recommend that the variety of relied on feedbacks can help users to conquer such manipulation in which the number of relied on feedbacks offers the evaluator a touch in figuring out the remarks credibility. But, the quantity of feedbacks isn't always sufficient in figuring out the credibility of believe feedbacks. for example, think there are two one-of-a-kind cloud offerings s_x and s_y and the aggregated consider feedbacks of both cloud services

are high (i.e., s_x has 89% advantageous feedbacks from one hundred fifty feedbacks, sy has 92% positive feedbacks from a hundred and fifty feedbacks). Intuitively, users have to continue with the cloud provider that has the better aggregated agree with feedbacks (e.g., s_y in our case). however, a self-selling attack might have been achieved on cloud service s_y, which method s_x should were decided on as a substitute. to conquer this hassle, we introduce the idea of feedback density to guide the determination of credible consider feedbacks. Especially, we consider the entire variety of customers who give believe feedbacks to a selected cloud provider because the comments mass, the general range of consider feedbacks given to the cloud service because the feedback quantity. the feedback extent is prompted by means of the comments extent collusion element which is controlled via a detailed quantity collusion threshold. This aspect regulates the multiple agree with feedbacks quantity that might collude the general depended on feedback quantity. As an instance, if the volume collusion threshold is ready to 15 feedbacks, any person c who offers greater than 15 feedbacks is taken into consideration to be suspicious of related to in feedback extent collusion. The comments density of a positive cloud provider s, d(s), is calculated as follows:

where $M(s)$ denotes the total number of users who give

$$q_{c,t} = \frac{\sum_{c=1}^{c=m} \left(\mathcal{A}_p(v_{c,t})\right)}{|a_t|} \quad (5)$$

feedback to cloud service *s* (i.e., the feedback mass).

Occasional Feedback Collusion: Considering the fact that collusion attacks against cloud services arise sporadically, we take into account time as an critical factor in detecting occasional and periodic collusion attacks (i.e., periodicity). In other phrases, we consider the overall quantity of trust feedbacks jV(s)j given to cloud provider s for the duration of a

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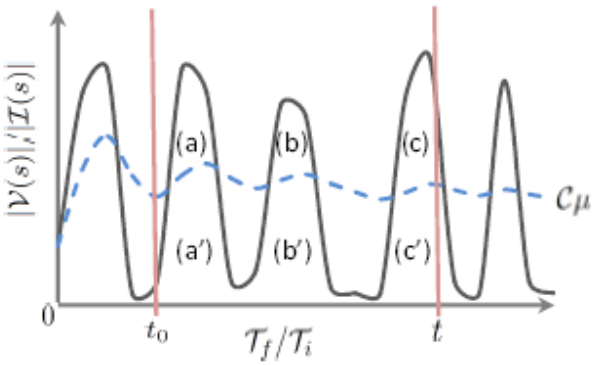
time period [t0, t]. A surprising exchange in the comments behavior suggests probable and occasional remarks collusion because the change of the wide variety of consider feedbacks given to a cloud service appear all at once in a quick time frame. To hit upon such conduct, we degree the share of occasional trade



in the total wide variety of feedbacks some of the complete remarks conduct (i.e., users' conduct in giving feedbacks for a sure cloud carrier). The occasional remarks collusion component Of (s, t0, t) of cloud service s in a time frame [t0, t], is calculated as follows:

where the first part of the numerator represents the whole area under the curve which represents the feedback behavior for the cloud service s. The second one a part of the numerator represents the intersection among the place beneath the curve and the place beneath the cumulative imply of the entire number of trust feedbacks (i.e., the region a′ ∪ b′ ∪ c′ in parent 2). cμ (jv(s, t)j) represents the mean of all factors within the overall wide variety of consider feedbacks and as much as the final element because the suggest is dynamic and changes every now and then. the denominator represents the complete area under the curve. As a result, the occasional collusion attacks detection is primarily based on measuring the occasional change inside the overall number of agree with feedbacks in a time period. the better the occasional change within the overall number of agree with feedbacks, the much more likely that the cloud provider has been laid low with an occasional collusion assault.

Sybil attacks detection:

Multi-identity popularity: Because users have to check in their credentials on the accept as true with identity registry, we accept as true with that multi-identity reputation is applicable via evaluating the values of customers' credential attributes from the identification records i. the main aim of this aspect is to shield cloud services from malicious customers who use a couple of identities (i.e., sybil attacks) to control the believe effects. in a typical accept as true with identity registry, the whole identity statistics i are represented as a listing of m customers' number one identities cp = fp1, p2, ..., pmg (e.g., user name) and a list of n credentials' attributes ca = fa1, a2, ..., ang (e.g., passwords, postal deal with, ip deal with, computer name). In other words, the entire cpca (customer's primary identity- credentials' attributes) matrix, denoted as im, covers all users who registered their credentials in tms. The credential characteristic fee for a selected customer vc;t is saved in tms with out consisting of credentials with sensitive facts the usage of the zkc2p (see phase three). we argue that tms can pick out patterns in customers'

anonymous credentials. Malicious users can use comparable credentials in exceptional identification facts i. therefore, we translate im to the multi-identification recognition matrix, denoted as mirm, which in addition covers the whole identity facts i represented as the whole cp ca matrix. However, the

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value for a specific patron qc;t within the new matrix represents the frequency of the credential attribute value for the same particular consumer *vc;t* in the same credential attribute (i.e., attribute *at*). The frequency of a particular credential attribute value *vc;t*, denoted as *qc;t*, is calculated as the number of times of appearance (denoted as *Ap*) that the credential value appears in the *tth* credential attribute normalized by the total number of identity records (i.e., the length of *at*) as follows:

Occasional Sybil Attacks:

Malicious users may manipulate trust results to disadvantage particular cloud services by creating multiple accounts and giving misleading feedbacks in a short period of time (i.e., Sybil attacks). To overcome the occasional Sybil attacks, we consider the total number of established identities *jI*(*s*)*j* for users who give feedbacks to cloud service *s* during a period of time [*t*0, *t*]. The sudden changes in the total number of established identities indicates a possible occasional

$$\mathcal{M}_{id}(c) = 1 - \left(\sum_{t=1}^{t=n} q_{c,t} \right) \qquad (6)$$

Sybil attack. To detect such behavior, we measure the percentage of occasional change in the total number of established identities among the whole identity behavior (i.e., all established identities for users who gave feedback to a particular cloud service). Similarly,

$$C_r(c,s,t_0,t) = \frac{1}{\lambda} * (\rho * \mathcal{D}(s) + \phi * \mathcal{O}_f(s,t_0,t) + \Omega * \mathcal{M}_{id}(c) + \iota * \mathcal{O}_i(s,t_0,t)) \qquad (8)$$

the occasional Sybil attacks factor *Oi*(*s*, *t*0, *t*) of cloud service *s* in a period of time [*t*0, *t*], is calculated as follows:

$$\mathcal{O}_i(s,t_0,t) = 1 - \left(\frac{\left(\int_{t_0}^{t} |\mathcal{I}(s,t)| \, \mathrm{d}t \right) - \left(\int_{t_0}^{t} \Delta_i(s,t) \mathrm{d}t \right)}{\int_{t_0}^{t} |\mathcal{I}(s,t)| \, \mathrm{d}t} \right)$$

$$where \Delta_i(s,t) = \begin{cases} \mathcal{C}\mu\left(|\mathcal{I}(s,t)|\right) & if\ |\mathcal{I}(s,t)| \geq \\ & \mathcal{C}\mu\left(|\mathcal{I}(s,t)|\right) \\ |\mathcal{I}(s,t)| & otherwise \end{cases} \qquad (7)$$

Feedback Credibility:

Based on the proposed credibility metrics, TMS dilutes the influence of those misleading feedbacks by assigning the credibility aggregated weights *Cr*(*c*, *s*, *t*0, *t*) to each trust feedback as shown in Equation 1. *Cr*(*c*, *s*, *t*0, *t*) is calculated as follows:

Change Rate of Trust Results:

To allow TMS to adjust trust results for cloud services that have been affected by malicious behaviors, we introduce an additional factor called the *change rate of trust results*. The idea behind this factor is to compensate the affected cloud services by the same percentage of damage in the trust results. Given *Con*(*s*, *t*0) the conventional model (i.e., calculating the trust results without considering the proposed approach) for cloud service *s* in a previous time instance, *Con*(*s*, *t*)

$$\mathcal{C}_t(s,t_0,t) = \begin{cases} \frac{\mathcal{C}on(s,t_0)}{\mathcal{C}on(s,t)} + 1 & if\ \mathcal{C}on(s,t) < \mathcal{C}on(s,t_0) \\ & and \\ & 1 - \mathcal{C}_r(c,s,t_0,t) \geq e_t(s) \\ 0 & otherwise \end{cases} \qquad (9)$$

the conventional model for the same cloud service calculated in a more recent time instance, the credibility aggregated weights *Cr*(*c*, *s*, *t*0, *t*), and *et*(*s*) the attacks percentage threshold. The change rate of trust results factor *Ct*(*s*, *t*0, *t*) is calculated as follows:

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5 THE AVAILABILITY MODEL:

Guaranteeing the availability of the Trust management provider (tms) is a enormous challenge because of the unpredictable wide variety of invocation requests that tms has to address at a time, in addition to the dynamic nature of the cloud environments. in cloudarmor, we endorse an availability version, which considers numerous elements which include the operational strength to allow tms nodes to percentage the workload and replication willpower to reduce the failure of a node hosting tms example. These factors are used to spread several allotted tms nodes to manipulate agree with feedbacks given via users in a decentralized manner.

Operational electricity

In our technique, we suggest to spread tms nodes over diverse clouds and dynamically direct requests to the ideal tms node (e.g., with decrease workload), in order that its favored availability stage can be usually maintained. it's far critical to increase a mechanism that allows decide the ultimate variety of tms nodes because extra nodes dwelling at numerous clouds way better overhead (e.g., cost and resource intake along with bandwidth and storage space) even as decrease

$$\mathcal{O}_p(s_{tms}) = \frac{1}{2} * \left(\sqrt{\left(\frac{\mathcal{V}(s_{tms})}{\mathcal{V}(all_{tms})} - \frac{\mathcal{V}(mean_{tms})}{\mathcal{V}(all_{tms})} \right)^2} + \frac{\mathcal{V}(s_{tms})}{\mathcal{V}(all_{tms})} \right) \quad (10)$$

range of nodes way much less availability. to take advantage of the load balancing method, we suggest that every node web hosting a tms instance reports its operational strength. the operational electricity aspect compares the workload for a selected tms node with the common workload of all tms nodes. the operational power for a specific tms node, op(stms), is calculated because the imply of the euclidean distance (i.e., to degree the distance between a selected tms node workload and the imply of the workload of all tms nodes) and the tms node workload (i.e., the proportion of agree with feedbacks treated by way of this node) as follows:

$$\mathcal{N}_{tms} = \begin{cases} \mathcal{N}_{tms} + 1 & if \quad \mathcal{O}_p(s_{tms}) \geq e_w(s_{tms}) \\ & or \quad \mathcal{N}_{tms} < 1 \\ \mathcal{N}_{tms} & otherwise \end{cases} \quad (11)$$

Replication will power:

In CloudArmor, we advise to exploit replication strategies to limit the opportunity of the crashing of a node hosting a TMS example (e.g., overload) to make certain that customers can deliver accept as true with feedbacks or request a agree with evaluation for cloud services. Replication allows TMS instance to recover any lost records during the down time from its replica.

$$\mathcal{A}(s_{tms}, t) = 1 - F(t) + \int_0^t m(x)(1 - F(t - x))dx \quad (12)$$

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Particularly, we recommend a particle filtering technique to precisely are expecting the provision of every node web hosting a TMS instance which then will be used to decide the best range of the TMS instance's replicas. To predict the supply of each node, we version the TMS instance as a right away (or factor) availability.

$$\mathcal{A}(s_{tms}, s) = \frac{1 - f(s)}{s(1 - f(s)m(s))} = \frac{s + \mu}{s(s + \mu + \lambda)} \qquad (13)$$

To this point, we can model the TMS instance's availability prediction problem via defining the state function and measurement function respectively by using:

$$\mathcal{A}(s_{tms}, t) = 1 - \frac{\lambda}{\mu}(1 - e^{-\mu t}) \qquad (14)$$

Trust Result Caching

Due to the fact that several credibility factors are considered in CloudArmor when computing the trust result for a particular cloud service, it would be odd if the TMS instance retrieves all trust feedbacks given to a particular cloud service and computes the trust result every time it receives a trust assessment request from a user. Instead we propose to cache the

$$\begin{aligned} z(t+1) &= \mathcal{A}(s_{tms}, t) + \epsilon_z \\ y(t+1) &= z(t+1) + \epsilon_y \qquad (15) \\ where \quad \epsilon_z &\sim \mathcal{N}(0, \sigma_z^2), \epsilon_y \sim \mathcal{N}(0, \sigma_y^2) \end{aligned}$$

Algorithm 1 Particle Filtering based Algorithm

1. **Initialization:** compute the weight distribution $\mathcal{D}_w(\mathcal{A}(s_{tms}))$ according to prior knowledge on replicas, e.g., the IP address of server hosting replicas etc.
2. **Generation:** generate the particle set and assign the particle set containing $\mathcal{N}$ particles
   - generate initial particle set $\mathcal{P}_0$ which has $\mathcal{N}$ particles, $\mathcal{P}_0 = (p_{0,0}, p_{0,1}, ...p_{0,\mathcal{N}-1})$ and distribute them in a uniform distribution in the initial stage. Particle $p_{0,k} = (\mathcal{A}(s_{tms})_{0,k}, weight_{0,k})$
   - assign weight to the particles according to our weight distribution $\mathcal{D}_w(\mathcal{A}(s_{tms}))$.
3. **Resampling:**
   - Resample $\mathcal{N}$ particles from the particle set from a particle set $\mathcal{P}_t$ using weights of each particles.
   - generate new particle set $\mathcal{P}_{t+1}$ and assign weight according to $\mathcal{D}_w(\mathcal{A}(s_{tms}))$
4. **Estimation:** predict new availability of the particle set $\mathcal{P}_t$ based on availability function $\mathcal{A}(s_{tms}, t)$.
5. **Update:**
   - recalculate the weight of $\mathcal{P}_t$ based on measurement m, $w_{t,k} = \prod(\mathcal{D}_w(\mathcal{A}(s_{tms})_{t,k}))(\frac{1}{\sqrt{2\pi}\sigma_y})exp(-\frac{\delta\mathcal{A}(s_{tms})_{t,k}^2}{2\sigma_y^2})$, where $\delta\mathcal{A}(s_{tms})_k = m_{\mathcal{A}}(s_{tms}) - \mathcal{A}(s_{tms})_{t,k}$
   - calculate current availability by mean value of $p_t(\mathcal{A}(s_{tms})_t)$
6. Go to step 3 and iteration until convergence

$$e_a(s_{tms}) < \mathcal{A}(s_{tms}, t)^{r(s_{tms})} \qquad (16)$$

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trust results and the credibility weights based on the number of new trust feedbacks to avoid unnecessary trust result computations. The caching process is controlled by two thresholds: one for users *eCache*(*c*) and one for cloud services *eCache*(*s*). If the TMS instance receives a trust assessment request from a user, it should use the trust result in the cache as much as possible, instead of computing the trust result from scratch. The TMS instance updates the cache based on the number of new trust feedbacks (i.e., since the last update) given by a particular consumer *jVc*(*c*, *s*)*jCache* and the number of new trust feedbacks given to a particular cloud service *jV*(*s*)*jCache*. The caching process is briefly shown in Algorithm 2.

Algorithm 2 Trust Results & Credibility Weights Caching Algorithm

Input: s, **Output**: $\mathcal{T}r(s)$

Count $|\mathcal{V}c(c,s)|_{Cache}$ /*TMS instance counts the total number of new trust feedbacks given by a particular consumer*/

if $|\mathcal{V}c(c,s)|_{Cache} \geq e_{Cache}(c)$ **then** /*TMS determines whether a recalculation is required for credibility factors related to the consumer*/

Compute $\mathcal{J}(c)$; Compute $\mathcal{B}(c)$

Compute $\mathcal{M}_{id}(c)$; Compute $\mathcal{C}r(c,s)$

end if

Count $|\mathcal{V}(s)|_{Cache}$ /*TMS instance counts the total number of new trust feedbacks given to a particular cloud service*/

if $|\mathcal{V}(s)|_{Cache} \geq e_{Cache}(s)$ **then** /*TMS determines whether a recalculation is required for credibility factors related to the cloud service including the trust result*/

Compute $\mathcal{D}(s)$; Compute $\mathcal{C}r(c,s)$

Compute $\mathcal{T}r(s)$

end if

$$r(s_{tms}) > log_{\mathcal{A}(s_{tms},t)}(e_a(s_{tms})) \quad (17)$$

Instances management:

In cloudarmor, we advocate that one tms example acts

Algorithm 3 Instances Management Algorithm

1. **Initialization:** $tms_{id}(0)$ computes $\mathcal{O}_p(s_{tms})$ for all trust management service nodes if any
2. **Generation:** $tms_{id}(0)$ estimates $\mathcal{N}_{tms}$ and generates additional trust management service nodes if required
3. **Prediction:** $tms_{id}(0)$ predicts new availability of all trust management service nodes $\mathcal{A}(s_{tms},t)$ using Algorithm 1
4. **Replication:** $tms_{id}(0)$ determines $r(s_{tms})$, and generate replicas for each trust management service node
5. **Caching:** $tms_{id}(0)$ starts caching trust results (consumer side) and $tms_{id}(s)$ start caching trust results (cloud service side) using Algorithm 2
6. **Update:** All $tms_{id}(s)$ update the frequency table
7. **Check Workload 1:** $tms_{id}(0)$ checks whether $e_w(s_{tms})$ is triggered by any $tms_{id}(s)$ before reallocation

if $\mathcal{O}_p(s_{tms}) \geq e_w(s_{tms})$ and $\mathcal{V}(s_{tms}) \geq \mathcal{V}(mean_{tms})$ **then**

go to next step

else

go to step 3

end if

8. **Reallocation:**
   - $tms_{id}(0)$ asks $tms_{id}(s)$ which triggered $e_w(s_{tms})$ to reallocate all trust feedbacks of the cloud service that has the lowest $|\mathcal{V}(s)|$ to another $tms_{id}(s)$ that has the lowest $\mathcal{V}(s_{tms})$
   - perform step 6
9. **Check Workload 2:** $tms_{id}(0)$ computes $\mathcal{O}_p(s_{tms})$ for all trust management service nodes and checks whether $e_w(s_{tms})$ is triggered for any $tms_{id}(s)$ after reallocation

if $\mathcal{O}_p(s_{tms}) \geq e_w(s_{tms})$ and $\mathcal{V}(s_{tms}) \geq \mathcal{V}(mean_{tms})$ **then**

go to step 2

else

go to step 3

end if

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as the principle example whilst the rest instances act as ordinary times. the primary instance is liable for the most appropriate range of nodes estimation, feedbacks reallocation, trust end result caching (purchaser facet), availability of each node prediction, and tms example replication. regular times are responsible for believe evaluation and feedback garage, the accept as true with end result caching (cloud carrier side), and frequency desk update. algorithm 3 suggests the quick system on how tms instances are controlled.

Example 1: Reallocation ($e_w(s_{tms})$ = 50%)

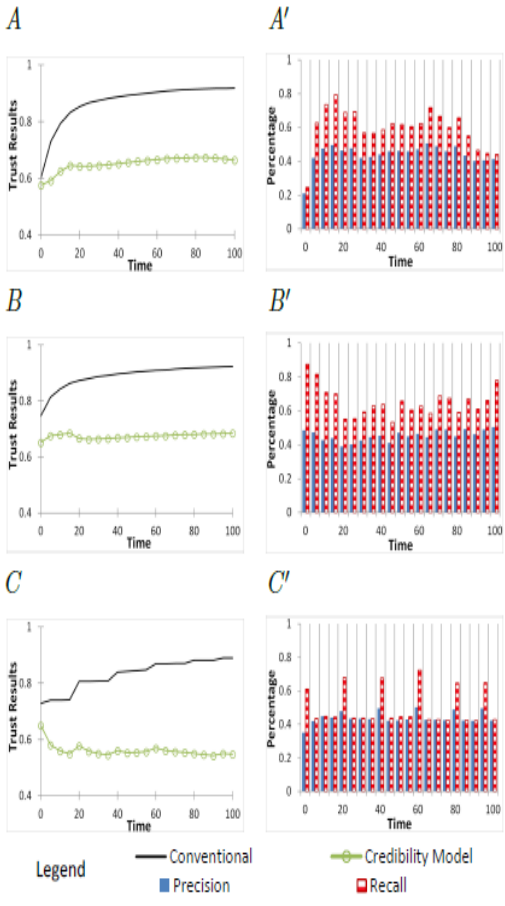
Frequency Table Before Reallocation (Step 1)
($tms_{id}(1)$, $|\mathcal{V}(1)|$: 200, $|\mathcal{V}(2)|$: 150, $|\mathcal{V}(3)|$: 195)
($tms_{id}(2)$, $|\mathcal{V}(4)|$: 30, $|\mathcal{V}(5)|$: 20, $|\mathcal{V}(6)|$: 45)
($tms_{id}(3)$, $|\mathcal{V}(7)|$: 90, $|\mathcal{V}(8)|$: 35, $|\mathcal{V}(9)|$: 95)

Check Workload (Step 2)
($tms_{id}(1)$, $\mathcal{O}_p(1_{tms})$: 0.617)
($tms_{id}(2)$, $\mathcal{O}_p(2_{tms})$: 0.278)
($tms_{id}(3)$, $\mathcal{O}_p(3_{tms})$: 0.205)

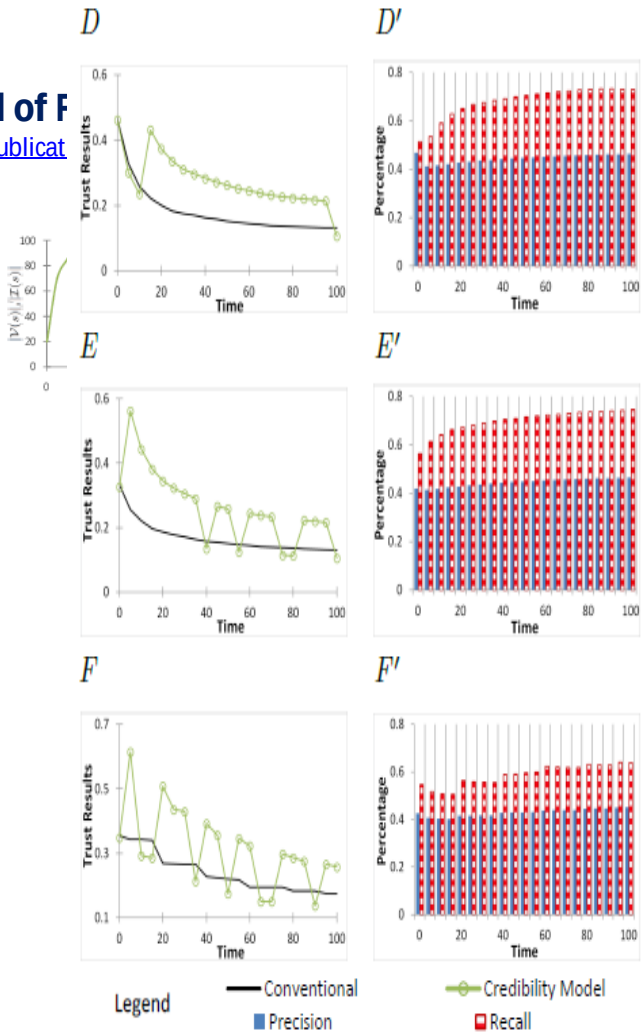
Frequency Table After Reallocation (Step 3)
($tms_{id}(1)$, $|\mathcal{V}(1)|$: 200, $|\mathcal{V}(3)|$: 195)
($tms_{id}(2)$, $|\mathcal{V}(2)|$: 150, $|\mathcal{V}(4)|$: 30, $|\mathcal{V}(5)|$: 20, $|\mathcal{V}(6)|$: 45)
($tms_{id}(3)$, $|\mathcal{V}(7)|$: 90, $|\mathcal{V}(8)|$: 35, $|\mathcal{V}(9)|$: 95)

6. IMPLEMENTATION AND EXPERIMENTAL Evaluation:

on this segment, we document the implementation and experimental consequences in validating the proposed approach. Our implementation and experiments have been developed to validate and take a look at the overall performance of each the credibility model and the provision version. **6.1 system Implementation:** The accept as true with control carrier's implementation is a component of our huge studies assignment, named CloudArmor2, which gives a platform for reputation-primarily based accept as true with management of cloud services. The platform presents an environment wherein users can provide feedback and request accept as true with evaluation for a particular cloud carrier. specially, the agree with management service (TMS) consists of essential components: the trust statistics Provisioning and the believe evaluation feature. The trust records Provisioning. This component is accountable for gathering cloud offerings and accept as true with records. We evolved the Cloud offerings Crawler module based at the Open supply web Crawler for Java (crawler4j3) and prolonged it to allow the



platform to routinely discover cloud services on the internet. We applied a fixed of functionalities to simplify the crawling system and made the crawled statistics extra comprehensive (e.g., addSeeds(), selectCrawlingDomain(), addCrawlingTime()). in addition, we advanced the consider Feedbacks Collector module to gather feedbacks at once from customers within the shape of history data and stored them inside the agree with Feedbacks Database. indeed, users commonly must set up their identities for the first time they try and use the platform via registering their credentials on the identification management carrier (IdM) which shops the credentials in the trust identification Registry. furthermore, we developed the identification info Collector module to gather the entire range of hooked up identities a number of the whole identity conduct (i.e., all established identities for customers who gave feedbacks to a selected cloud carrier). The believe evaluation feature. This function is accountable for managing consider assessment requests from users where the trustworthiness of cloud offerings are as compared and the factors of agree with feedbacks are calculated (i.e., the credibility factors). We evolved the elements Calculator for attacks detection based totally on a set of things (greater info on how the credibility factors are calculated may be observed in section 4). moreover, we developed the consider Assessor to compare the trustworthiness of cloud offerings via soliciting for the aggregated elements weights from the elements Calculator to weigh feedbacks after which calculate the mean of all feedbacks given to every cloud carrier. The agree with consequences for



each cloud service and the factors' weights for consider feedbacks are stored within the trust effects and factors Weights garage.

Experimental Evaluation

We particularly focused on validating and studying the robustness of the proposed credibility model against different malicious behaviors, namely collusion and Sybil attacks under several behaviors, as well as the performance of our availability model.

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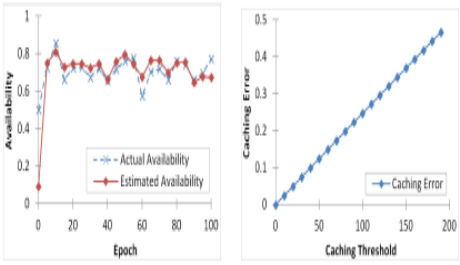
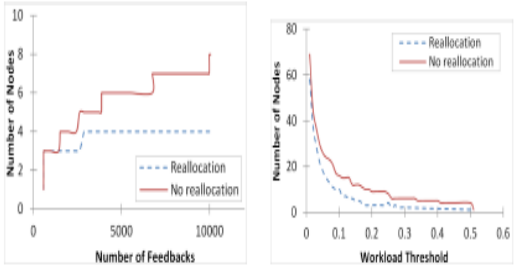


(a) Actual Availability VS. Esti- mated Availability (b) Trust Results Caching Error Rate

availability version experiments:

we examined our availability version using the equal

TABLE 1
Behavior Experimental Design



(a) Number of TMS Nodes VS. Feedbacks (b) Number of TMS Nodes VS. Workload Threshold

dataset we amassed to validate the credibility model. however, for the availability experiments, we focused on validating the provision prediction accuracy, believe results caching accuracy, and reallocation performance of the availability model (i.e., to validate the three proposed algorithms which includes particle filtering primarily based set of rules, trust results & credibility weights caching algorithm, and times control algorithm).

7 Related work:

over the past few years, accept as true with management has been one of the warm topics mainly in the place of cloud computing. some of the research efforts use coverage-based agree with management techniques. as an instance, Ko et al suggest TrustCloud framework for duty and accept as true with in cloud computing. mainly, TrustCloud includes 5 layers which include workflow, information, machine, regulations and laws, and regulations layers to cope with duty in the cloud environment from all elements. All of these layers hold the cloud responsibility existence cycle which includes seven levels including policy making plans, sense and trace, logging, secure-preserving of logs, reporting and replaying, auditing, and optimizing and rectifying. Brandic et al. endorse a novel approach for compliance control in cloud environments to set up agree with between special events. The method is developed using a centralized architecture and uses compliant control approach to establish believe among cloud carrier users and cloud service vendors. not like previous works that use policy-primarily based agree with management techniques, we check

the trustworthiness of a cloud carrier the use of reputationbased accept as true with control techniques. popularity represents a excessive influence that cloud provider customers have over the trust control device, specially that the reviews of the numerous cloud provider users can dramatically affect the popularity of a cloud carrier both positively or negatively. some research efforts also don't forget the reputationbased accept as true with management strategies. as an example, Habib et al. propose a multi-faceted accept as true with control (TM) system architecture for cloud computing to assist the cloud service users to perceive

trustworthy cloud carrier providers. specially, the architecture fashions uncertainty of consider records gathered from a couple of sources the usage of a set of pleasant of provider (QoS) attributes together with security, latency, availability, and customer aid. The structure combines two distinct accept as true with control strategies which includes popularity and advice in which operators (e.g., AND, OR, now not, FUSION, CONSENSUS, and DISCOUNTING) are used. Hwang et al. [4] recommend a safety aware cloud architecture that assesses the agree with for each cloud service providers and cloud provider users. to evaluate the trustworthiness of cloud carrier vendors, the authors suggest the consider negotiation method and the statistics coloring (integration) using fuzzy logic strategies. To verify the trustworthiness of cloud carrier customers, they develop the allotted-Hash-desk (DHT)-primarily based trustoverlay networks among several records facilities to deploy a reputation-based agree with control approach. in contrast to previous works which do not recall the trouble of unpredictable popularity assaults in opposition to cloud services, we gift a credibility version that not only detects the deceptive believe feedbacks from collusion and Sybil assaults, however also has the capability to adaptively alter the trust outcomes for cloud offerings which have been affected by malicious behaviors.

8 CONCLUSIONS:

Given the especially dynamic, disbursed, and nontransparent nature of cloud offerings, handling and setting up believe between cloud provider users and cloud offerings stays a enormous task. Cloud provider customers' feedback is a superb source to evaluate the general trustworthiness of cloud services. however, malicious users might also collaborate collectively to i) disadvantage a cloud carrier by means of giving more than one misleading believe feedbacks (i.e., collusion attacks) or ii) trick users into trusting cloud services that are not straightforward by using creating numerous money owed and giving deceptive believe feedbacks (i.e., Sybil attacks). in this paper, we have presented novel strategies that assist in detecting reputationbased assaults and permitting customers to successfully perceive trustworthy cloud services. particularly, we introduce a credibility version that no longer simplest identifies misleading believe feedbacks from collusion assaults but also detects Sybil assaults irrespective of these attacks take region in a lengthy or quick time frame (i.e., strategic or occasional assaults respectively). We also increase an availability version that keeps the accept as true with management carrier at a desired degree. we've amassed a big quantity of consumer's consider feedbacks given on actual-international cloud services (i.e., over 10,000 information) to assess our proposed techniques. The experimental outcomes demonstrate the applicability of our approach and display the capability of detecting such malicious behaviors. There are a few guidelines for our destiny paintings. We plan to mix one of a kind trust control techniques which include popularity and recommendation to growth the accept as true with effects accuracy. overall performance optimization of the trust control service is some other awareness of our future research paintings.

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