The Sybil Attack - Theory and Practice

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Abstract

1 Introduction

Electronic commerce and online social networking are common events at the present time. They allow us to orchestrate many aspects of our lives in the comfort of our homes, behind the monitors of our devices. An online identity is often required to use such services, for examples we must create an account to use tweet[1] our friend who must also have an account. In this scenario, users can choose to remain psudonymous if they are careful, where their real-life identity is uncorrelated with their online identity.

While creating pseudonyms is a useful for protecting users' privacy, it also opens a alleyway for attackers. The Sybil attack, first described by Douceur[15], is an attack where an entity can assume multiple identities or Sybils, and then attack either another entity or undermine the whole system. For example, a malicious twitter user can create many fake identities and have the fake identities follow his read identity, thus creating a false reputation. It is one of the most important attacks because it leads to a large number of consequences including but not limited to spreading false information, ballot stuffing[6] and eclipse attacks[53]. Furthermore, to the best of our knowledge, there is no general solution for preventing the Sybil attack.

In this work, we survey both the theory and practical aspects of the Sybil attack. Section 2 describes the Sybil attack in more detail and outlines some of the theoretical results. Then we look at how researchers and

[1] A message sent using Twitter is a tweet.

black-hat hackers mounted the Sybil attack on real-world e-commerce and online social network systems. There is a large variety of Sybil attack defence mechanisms, from using trusted-third-party to exploiting the graph characteristics in online social networks, thus we classify those mechanisms by their "main idea" in 3. Finally we present the related work in this area in Section 4.

2 The Sybil Attack

The Sybil attack is coined by Douceur[15] in 2002 in the context of peer-to-peer systems. Preventing the Sybil attack is in fact a lot more difficult because peer-to-peer systems often do not have a central, trusted authority. So it is always possible to create new identities.

Important theoretical results: Sybil-proof[8] - symmetric reputation functions cannot provide Sybil-proofness, must use asymmetric reputation functions.

a test bed for sybil attacks[24]

Quantifying Sybil attack[36]

3 Defences

In this section we categorise various defence techniques against the sybil-attack in reputation systems.

3.1 Trusted Third Party

One of the earliest and best known reputation system is eBay[44]. The buyers and sellers rely on a trusted third party, in this case eBay, to gather and distribute feedbacks after every transaction. Even when there are no incentives to provide feedback, Resnick and Zeckhauser observed that feedback was provided more than half of the time[44], making eBay one of the most well-known online marketplaces.

In general, trusted third parties manage the issurance and verification of identities. Thus they can apply a fee on the peer for creating a new identity[43] or rate-limit the creation of new identities[15], making sybil-attacks more difficult. Furthermore, trusted third parties often have the

ability to manipulate the identities. For example they could punish the attackers by disabling all of their identity when caught, making the sybil-attack much riskier especially when identities are costly.

Trusted third party is likely the most widely used technique in practice. Marketplaces such as Amazon or eBay, online forums such as Stackoverflow or Reddit, all use a form of trusted third party.

Unfortunately, a trusted third party is often a single point of failure. Moreover, being a centralised system, it is difficult to scale up to suit increasing user demands. In the remainder of this section, we focus on distributed techniques for preventing the sybil-attack.

Credence 06[63] - uses central authority to sign key

3.2 Costly Identity Creation

3.2.1 IP Address

3.2.2 Low reputation for new users

Feldman 04[16] - adaptive stranger, low score on entry

3.3 Indirect Information

EigenTrust[28] - doesn't prevent sybils, suggests to add cost in ID creation R2Trust[58] - credibility, tackles colluders, time decay factor

3.4 Graph Techniques

Theory[50] Gal-Oz et al. [17] communities are collection of knots, sybils can form a knot? Regret[45, 46] - information from multiple dimensions Guha 04[18] - no mention of sybil attacks or attacks in general

3.4.1 Flow Based

BarterCast[39] SybilRes[12]

3.4.2 Topology

SybilGuard[70] SybilLimit[69] SybilInfer[11] SybilShield[51] - assuming sybils have bad connectedness SumUp[59] GateKeeper[60] - based on SumUp Social-network[61] - community detection

Distributed Sparse Cut Monitoring[31]

Other systems are built on top: ReDS[2] suggests to use sybilimit or sybilinfer SybilProof-DHT[33]

3.5 Reputation Transfer

Trust-transfer[48]

3.6 Self Registration

P-GRID 01[1] Self-registration[14] - distributed registration based on IP address

3.7 Cryptography Based Techniques?

Secure-Overlay[35] - ID crypto and SSS Privacy-preserving[47] - blockchain? Proof-of-stake[13] SybilConf[56]

3.8 Content Driven

[7]

3.9 Other

Parental control[57] - uses parents to "observe" find suspects, only for detection, requires a sybil-proof reputation scheme DSybil[68] - recommendation system, need historical data Symon[27] - pair peers together, likelihood for both to be sybils is low, the pair monitor each other to prevent attacks XRep 02[10] IP check, and checks digest, uses existing P2P systems like Gnutella

3.10 Unsorted?

Beth and PGP limits Sybil attack to some extent by using social graphs Beth 94[5] PGP (Zimmermann) 95[74]

Yu 00[67] Lee 03[32] - uses flooding, might not be scalable, only talks about DoS Marti 04[38] ARA 05[21] - no mention of sybil, prevents freeriding, prevents short-term abuse because reputation increases gradually FuzzyTrust Song 05[54] - uses fuzzy logic P2PRep/Fuzzy 06[4] - also fuzzy, does not

prevent generation of false rumors Xiong 05[65] - no mention of sybil, but tries to mitigate false information PowerTrust 06[73] - uses "power nodes" (from power-law), no mention of sybil, some defence against colluders

Histos and Sopras[71], doesn't really have structure? Beta[25] Gupta et al.[20]

PeerTrust[64] - DHT, used P-GRID source code, has credibility rating

PerContRep[66]

3.11 Does not handle Sybil-attack?

TrustMe[52] is a reputation that focuses on anonymity, no mention of sybil attack

H-Trust[72] does not mention sybil

Coner et al.[9] assumes clients cannot perform sybil attack

TrustGuard 05[55] - assumes it is built on secure overlay networks (sybil-proof networks)

Scrivener 05[41] - assumes ID cannot be created and discarded

4 Related Work

Reputation Surveys: [37] [26] ? [23] [30] [49] ? [22]

Sybil Surveys: [34] [40] [42] [19] [29] Sok[3] but also some contribution

Other: [62]

5 Summary

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