Emulation on the Internet Prefix Hijacking Attack Impaction

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Abstract. There have been many incidents of IP prefix hijacking by BGP protocol in the Internet. Attacks may hijack victim's address space to disrupt network services or perpetrate malicious activities such as spamming and DoS attacks without disclosing identity. The relation between network topology and prefix hijacking influence is presented for all sorts of hijacking events in different Internet layers. The impaction parameter is analyzed for typical prefix hijacking events in different layers. A large Internet emulation environment is constructed and the attack impaction of IP prefix hijacking events are evaluated. The results assert that the hierarchical nature of network influences the prefix hijacking greatly.

Keywords: IP prefix hijacking; Power law; BGP; Inter-domain routing system; Internet emulation environment.

1 Instruction

Prefix hijacking is also known as BGP hijacking, because to receive traffic destined to hijacked IP addresses, the attacker has to make those IP addresses known to other parts of the Internet by announcing them through BGP. Because there is no authentication mechanism used in BGP, a mis-behaving router can announce routes to any destination prefix on the Internet and even manipulate route attributes in the routing updates it sends to neighboring routers. Taking advantage of this weakness has become the fundamental mechanism for constructing prefix hijack attacks. They occur when an AS announces a route that it does not have, or when an AS originates a prefix that it does not own.

Previous efforts on prefix hijacking are presented from two aspects: hijack prevention and hijack detection. Generally speaking, prefix hijack prevention solutions are based on cryptographic authentications [4-8] where BGP routers sign and verify the origin AS and AS path of each prefix. While hijack detection mechanisms [9-15] are provided when a prefix hijack is going to happening which correction steps must follow. Because there is a lack of a general understanding on the impact of a successful

prefix hijack, it is difficult to assess the overall damage once an attack occurs, and to provide guidance to network operators on how to prevent the damage.

In this paper, we conduct a systematic study on the impaction prefix hijacks launched at different position in the Internet hierarchy. The Internet is classified into three hierarchies—core layer, forwarding layer and marginal layer based on the commercial relations between autonomous systems (ASes). And a large Internet emulation environment is constructed which hybridizes the network simulation technology and packet-level simulation technology to achieve a preferable balance between fidelity and scalability. The experiment results show that the hierarchical nature of network influences the prefix hijacking greatly.

The remainder of this paper is organized as follows: The related works are discussed in section 2. The impaction analysis of the prefix hijacks attack is presented in section 3, in which IP prefix hijacks are classified on a comprehensive attack taxonomy relying on the Internet hierarchy model and BGP protocol policies. Section 4 builds an emulation environment to test the correctness of our conclusion and section 5 concludes the paper.

2 Related work

Various prefix hijack events have been reported to NANOG [19] mailing list from time to time. IETF's rpsec (Routing Protocol Security Requirements) Working Group provides general threat information for routing protocols and in particular BGP security requirements [20]. Recent works [3,21] give a comprehensive overview on BGP security. The prefix hijacking is one of the key problems being noticed to BGP in these papers.

Previous works on prefix hijacking can be sorted into two categories: hijack prevention and hijack detection. The former one is trying to prevent the hijacking in the protocol mechanism level, and the latter one is trying to find and alert the hijacking event after it happening. The methods adopted can be categorized into two types: cryptography based and non-crypto based.

3 Analysis on Prefix Hijack Attack Impaction

3.1 Internet Hierarchy

In [18], we build a three-hierarchy model of the Internet and give an efficient arithmetic for it. The model is organized as follows:

a) The set of nodes who have no providers forms a clique (interconnection structure), which is the core layer.

b) If the nodes don't forward data for others, then it belongs to the marginal layer.

c) The node that belongs to neither the core layer nor the marginal layer belongs to the forwarding layer. And the forwarding layer has several sub-layers.

3.2 The relation between prefix hijacking and the Internet Hierarchy

For the simpleness of the description, the ASes whose prefixes being hijacked are expresses with V, and the hijack attack ASes are denoted by A. Furthermore, we suppose each AS only has one provider. The multi-home mechanism is not considered in this paper.

To evaluate the influence if prefix hijacking events, two impaction parameters are introduced as follows:

Definition 1 Set of the affected nodes *Nc*: The set of nodes whose routing states might be changing because of the happening prefix hijacking event.

Definition 2 Affected path factor μ: The percentage of the paths might be changed because of the happening prefix hijacking event.

In paper [23],we classified the prefix hijacking events into nine types according to the different positions which the attackers and victims are located. The relation between prefix hijacking and the Internet hierarchy are concluded by the two impaction parameters .

From the analysis, these results can be drawn:

1) The hijacked AS in the core layer is not the most awful thing. On the contrary, if the AS in the marginal layer being hijacked, the number of the affected nodes is the largest among the three levels;

2) The hijacked AS in the forwarding layer can affect more paths than the core layer or the marginal layer;

3) If the hijacked ASes are in the same level, the hijacking AS in the forwarding layer can affect more nodes than the core layer or the marginal layer, and the higher attacker is in, the larger its influence will be;

4) The sub-prefix hijack can affect more ASes than the same prefix hijack, and the lager sub-prefix range is, the bigger affected path factor μ will be.

4 Evaluation Environment and Experiment

In order to verify the correctness of the conclusions in section 3, we build a prefix hijacking attack emulation environment, which is composed of three Juniper J2350 routers and four server computers. Each server can emulate 30 virtual routers.

For the authenticity of the test, the real BGP data is samples for the topology of inter-domain system. According to the sampling rules in [22], a network with 110 ASes is build, and the commercial relations are reserved. The network is also be classified into layers by the hierarchical algorithm in section 3.

Each prefix hijacking cases, we repeat the attach process three times, and calculate the average values of the affected nodes number *Nc* and path factor μ. The results are described in Table 1.

From the expariment results, we can see that if the AS in the marginal layer being hijacked, the number of the affected nodes is the largest among the three levels; the hijacked AS in the forwarding layer can affect more paths than the core layer or the marginal layer; and the hijacking AS in the forwarding layer can affect more nodes than the core layer or the marginal layer.

Table 1. Experiment Results

Case	*Nc*	*μ*
V∈C, A∈C	13	43
V∈C, A∈F	24	53
V∈C, A∈S	18	36
V∈F, A∈C	28	118
V∈F, A∈F	34	78
V∈F, A∈S	21	62
V∈S, A∈C	32	75
V∈S, A∈F	57	73
V∈S, A∈S	28	65

5 Conclusion

This paper conducts a systematic study on the impaction prefix hijacks launched at different position in the Internet hierarchy based on the work in paper [23]. A large Internet emulation environment is constructed which hybridizes the network simulation technology and packet-level simulation technology to achieve a preferable balance between fidelity and scalability. The experiment results show that the hierarchical nature of network influences the prefix hijacking greatly.

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