Proposal Security Solutions to Protect Automation System from Denial of Service in Airports

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Abstract— In a denial of service (DoS), attackers may do attacks from a single device or from multiple devices that they control. Denial of service problem has great impact on all devices in Automation System (AS) in airports. A lot of techniques have been developed that can protect systems from DoS attack. This paper presents some proposal solutions to solve this problem in order to decrease the risk factor Using connecting the network with two routers. The first router is the basic and the other one is reserve. Then, dividing the devices in airports into normal and VIP devices, connecting VIP devices with two networks to prevent attackers from harm AS and the optimal solution mixing between the previous solutions, Trusted Authentication Device (TAD) and Trust Point (TP). AS will be more robust against a lot of kinds DoS attacks.

Index Terms— Automation Systems, denial of service, trusted point, counter, Trusted Authentication Device, Network to pology, Trust Point.

1 Introduction

Automation Systems (AS) are devices connected in a network of hardware and software, which controls and observes all sub systems like (Heating, Ventilation, and Air Conditioning (HVAC), Lighting, Fire Alarm, Elevators, etc.) . AS guarantees the best performance of the devices save time and energy and reduces operating costs as well as the comfort and safety of building occupants. A technical infrastructure is necessary to fulfill the previousdemands.
AS. is found where mechanical equipment, electrical systems and other equipments in building are joined with microprocessors that communicates with each other and to a computer. All devices in the automation system can be remote accessed through a computer, enabling the manager to view or control the system of the appliances from virtually any location through the internet. [1]
The airport operator should also ensure that the necessary communications infrastructure is provided, and that all necessary systems and procedures can be installed and operated. It is essential that information exchange between all airport users is coordinated and agreed upon, taking into account the technological solutions and standards best suited to each particularsituation, and in accordance with international standards. [2]
The goal of the automation system is to make airports as intelligent as possible .Centralized in this concern means that automatic control is done by a single controller or control station. AS has two levels of architecture as shown in Fig. 1, the two-level architecture consists of a control network level and a common backbone network which together form the automation network (AN). The control network is connecting the field devices. It has small bandwidth in the order of a few K bit/s. The management devices cannot be connected through this control network, control sub networks and management devices are connected via a high-bandwidth backbone network and this network is used to connect AS and foreign networks (e.g. Internet).

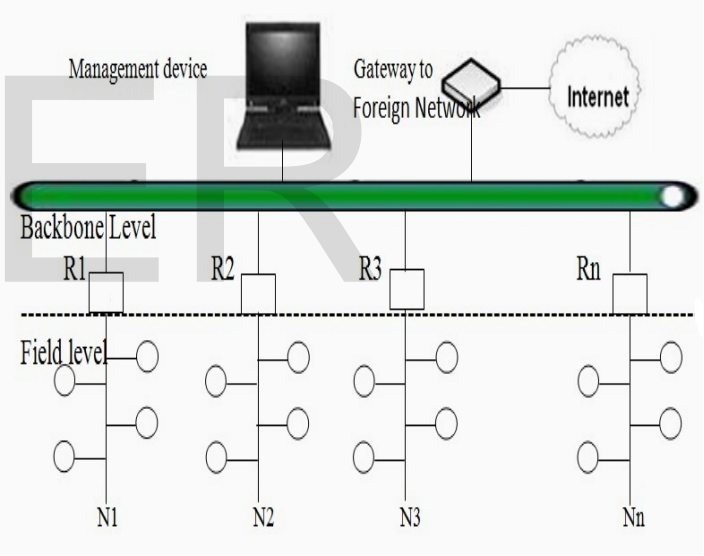


Fig. 1: Automation System Architecture [3]

Automation systems have a lot of attacks, these attacks have two types 1- Passive attacks – eavesdropping on or monitoring of transmissions (ex. Release of message contents and Traffic analysis) 2- Active attacks – modification of the data stream or creation of a false stream (ex. Masquerade , Replay, Modification of message and Denial of service).[3]

2 DoS and Types of Attacks

Automation systems require automatic information interchange among all system devices. We must create a secure environment which involves specifying a policy containing particular security demands .There are security attacks on automation system. Some of these attacks can be prevented through encryption, authentication and firewall techniques. There are some attacks which cannot be prevented by using Encryption and Authentication methods like Denial of service

(DoS) attacks. DoS. Attack is an attack on network, software and hardware of the system that make system or network(s) incapable of doing the functions designed to be performed, or to make the system services unavailable and prevent users from access to the system .Attackers can succeed to Dos by using network flooding, redirection, code injection and physical attack.
The first method is Flooding: flood the network, the attacker send packets to achieve not leaving enough bandwidth for the normal packets. [1, 3, 4]
The other method is to crash a hardware or software item and make it Unusable. Servers, routing devices are the common targets that could be damaged during an attack.

2.1 DoS Attacks

TABLE 1: ATTACKS, AFFECTED AREA AND DESCRIPTION [5]

	Attack	Affected Area	Description
1	Network level Device	Routers, IP Switches, Firewalls	Attack attempts to exhaust hardware resources using multiple duplicate packets or a software weakness.
2	OS Level	Equipment Vendor OS, End-User Equipment.	Attack takes advantage of the way operating systems implement protocols.
3	Application Level Attacks	Application software	Attack a service or machine by using an application attack to exhaust resource.
4	Data Flood (Amplification ,Oscillation, Simple Flooding)	Network	Attack in which massive quantities of data are sent to a target with the intention of using up bandwidth / processing resources.
5	Protocol Feature Attacks	Servers, Client PC	Attack in which weakness in protocol are used to take down network resources. Methods of attack include: IP address spoofing, and corrupting server cache.

In a denial of service, attackers may do attacks from a single device or from multiple devices that they control. When attackers attack systems from multiple devices or places that are distributed in the network, it is called a Distributed Denial of Service (DDoS) attack. But when attackers attack systems from a single device or place, it is called a Single-Source Denial of service (SDoS) attack. DDoS attacks have strong impact than SDoS attacks, because of the amount of bandwidth, CPU, memory that can be affected. In practice, protecting systems against DDoS attacks is proven to be harder than defending against SDoS attacks. [4, 5]
A DoS brute-force attack aims to prevent users from accessing to the service by sending a vast amount of seemingly valid service requests and trying to exhaust a key resource of the system. For example, in a User Datagram Protocol (UDP) flood attack, an attacker sends a high number of UDP segments to random devices on a system to consume its bandwidth; this makes systems not available to other users. [5]

2.2 Countermeasures for some DoS attacks

TABLE 2: ATTACKS, COUNTERMEASURE OPTIONS AND DESCRIPTION. [5]

	Attack	Countermeasure Options	Description
1	Network Level Device	Software updates, packet filtering	By updating software system we will fix some weakness and packet filtering can prevent attacking traffic from entering a network.
2	OS Level	SYN Cookies, drop backlog connections, shorten timeout time	Shortening the backlog time and dropping backlog connections will free up resources. SYN cookies proactively prevent attacks.
3	Application Level Attacks	Intrusion Detection System	Attack a service or machine by using an application attack to exhaust resources, IDS prevent these attacks
4	Data Flood	Replication and Load Balancing	Extend the volume of content under attack makes it more complicated and harder for attackers to identify services to attack and accomplish complete attacks.
5	Protocol Feature Attacks	Extend protocols to support security.	Trace source / destination packets by a means other than the IP address (blocks against IP address spoofing) and a lot of protocols provide authorization and authentication on entering to system

3 DoS Detection and Countermeasures

The most useful ways in the process of detect Dos are called intrusion detection systems (IDS).The main goal of IDS is to detect the misuse of the system by monitoring operations occurring in a computer system or network, prevent attempts to gain unauthorized access to a network or to create network degradation and analyze all operations which might be signs of possible incidents. They are imminent threats of violation of computer security policies, acceptable use policies, or standard security practices. [6]

Intrusion detection systems (IDS) as shown in Fig.2 primarily focus on identifying possible incidents, logging on information about them in order to stop them, and report them to security administrators. In addition, companies use IDSs in a lot of purposes, such as identifying problems with security policies, documenting existing threats, and deterring individuals from violating security policies.

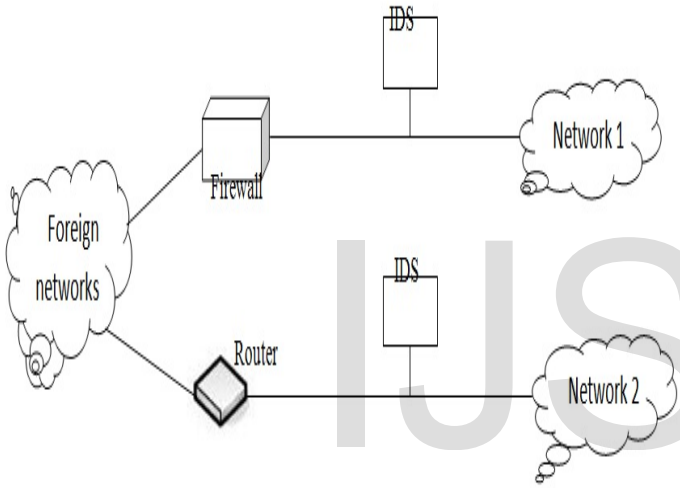


Fig. 2: IDS can be connected in network with or without firewall

After a Dos attack has been detected by the IDS, system must deactivate the port where a Dos attack has been detected and stay current with patches and security updates. You should config your applications, services, and operating system with denial of service in mind, activate the TCP/IP stack against denial of service. You should make sure your account lockout policies cannot be exploited to lock out well known service accounts, make sure your application is capable of handling high volumes of traffic and that thresholds are in place to handle abnormally high loads. Lastly, review the applications which the system fail to do , use a network Intrusion Detection System (IDS) because these can automatically detect and respond to attacks.IDS must have these features (high detection rates, low false negative alarms, low false positive alarms and quick detection rates) and use resource and bandwidth throttling techniques.[8]

Prevention of Dos requires the following actions:

1- High redundancy and high availability network design.

2- Perimeter Defence - Any packets must pass through firewalls to reach internal network.

3- Defence In-depth - Intruder Detection System (IDS) will allow detection and take action to remove infected packets. IDS may be able to detect known attacks but not new ways of these attacks.

4- Malware detection and prevention.

5-Periodic Scanning- Periodic network scanning will detect weakness host and detect new attacks.

6-Keeping the system up to date with patches or version upgrades, closing old services, applying Access Control Lists on the system and changing passwords every period and applying good password policies.[7,8]

4 Related Works

4.1 Virtual bridges

By using Virtual bridges, this will decrease risk factor as shown in Fig. 3. For example, the virtual bridge VB2 that is put in N2. This virtual bridge decreases the DoS-RF of all devices to 4 and alternative communication paths have to be provided by using redundant interconnections between virtual bridges and devices, for example, a redundant connection is added between VB2 and R2. Using this connection, the devices of VN22 are still able to connect with other networks. Applying this case, the Dos-RF of the devices of VN21decrease from 7 to 3. [9]

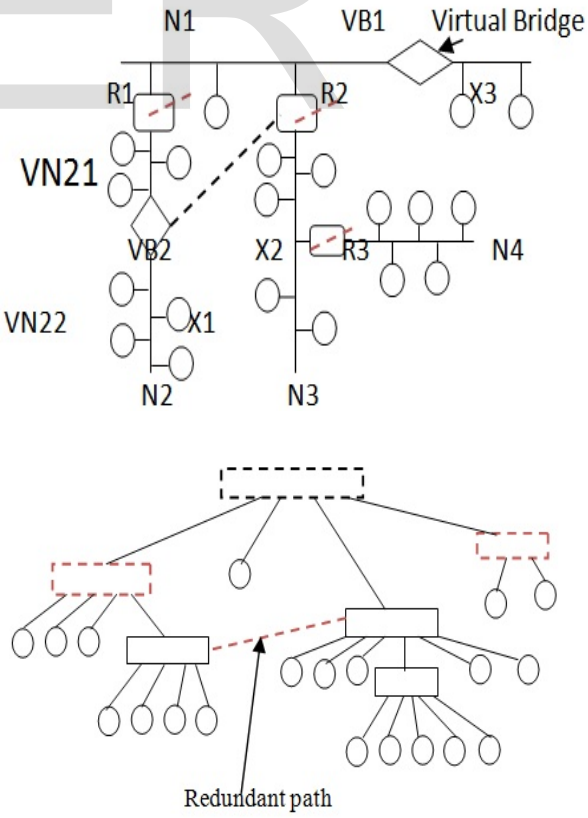


Fig. 3: Virtual bridges

4.2 Linux kernel

Linux Kernel Version 2.2.16 is the most useful way .It is considered to be immune to most poisoned traffic attacks like teardrop or TARGA. The backlog queue of the system defaults to 128 entries and TCPSYC cookies is enabled. After this, the system will be very robust against flood attacks. [10]

4.3 Linux virtual server

The load balancer which is used in the Linux Virtual Server (LVS). LVS inserts itself directly into the kernel and provides a maximum performance again. It stabilizes the system against overload attacks. LVS has two load balancing algorithms: round robin and least connection. By using 'least connection', we provide generally a fairer load distribution between the servers. [11, 12]

5 PROPSAL WORK

DoS is a very important problem in automation system in airports. This paper presents solutions to protect system which will be discussed to avoid interruptions in AS and to decrease the risk factor.

5.1 Connecting the network with two routers the first router is the basic and the other router is reserve.

The idea is connecting the network with two routers. The first router is the basic and the other router is reserve when any problem happen in the basic router, the system will activate the port to which the network is connected in a spare router. If IDS find attacks from the basic router or if a basic router doesn't send any data to the system for period, a system will deactivate the port in a basic router and activate the port in a spare router. But if a number of devices can connect with a router and connect the half of this number in each network, addresses must not be repeated in the two networks. This solution will decrease the risk factor and connect a number of devices in a network together.

Ex As shown in Fig. 4 connected N1 with port in R1 basic and with R2 spare, if any DoS attack happen in R1 AS. will deactivate R1 and activate R2. In this case the risk factor will be decreased to zero and the same will happen between N2, N3.

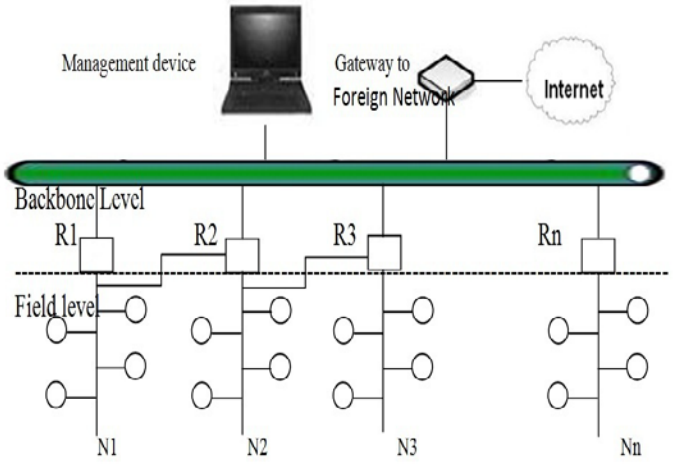


Fig. 4: first router is the basic and the other router reserve

5.2 Dividing the devices into normal and VIP devices and connecting VIP devices with two networks.

AS has a lot of benefits for any building which install on it but benefits would mean different things to different buildings. For industry, energy devices are more important, for bank security, in airports security, CCTV and runway lighting is important etc. In this solution, devices are devided to normal devices and VIP devices and connect all devices as shown in Fig. 5. VIP device in airports will connect with two networks if DoS happen in one network system will connect with this device through the other network. This way we will decrease the risk factor in VIP devices in airport to zero and in routers, normal devices will decrease risk factor to minimum.

Ex. As shown in Fig. 5 A, B, C, D routers and E, F, G VIP devices.

By connecting E With A,B routers and consider A basic , B spare when DoS attack or any error happened on A, system will connect to E through B and do the same for F and G devices.

If DoS attack happen on alink which connected between A and a backbone system will connect to A and other devices through E and B and do the same for other networks.

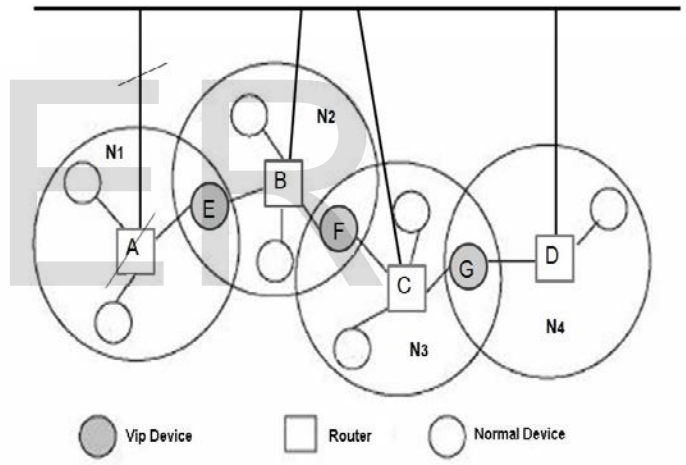


Fig. 5: Connect VIP devices in airport AS

5.3 An optimal solution which is mixing between the previous solutions.

In this solution Ring Topology will be used in connecting routers and devices, connecting VIP devices with two networks and using trust point to prevent attackers from access to automation system; this will decrease risk factor to minimal value.

- Using Trusted Authentication Device

  Trusted authentication device (TAD) should be found in AS to manage connecting between users and servers.

Users and server need to be registered in the TAD, only the registered users can connect to the system. Each server has all users signatures in access control list stored on it as shown in

Fig. 6.

Steps:

1-System Initialization

When system initialize, TA choose a set of parameters TA signature F and public key d and private key Q = F*d and hash function Z.

2- Registration of the user i

When user i is registered, he will send Ci (User signature) in the registration request,

It will get a set of parameters from TA including d, Ni (user private key), Qi (user public key), Z and Xi Where Xi= E (Ci*F, Ni)

3- Registration of Server j When server j is registered, it will send Sj (server signature) in the registration request, it will get a set of Parameters from the TA including d, Nj (Server private key), Qj (Server public key), Z and Xj Where Xj= E (Sj*F, Nj)

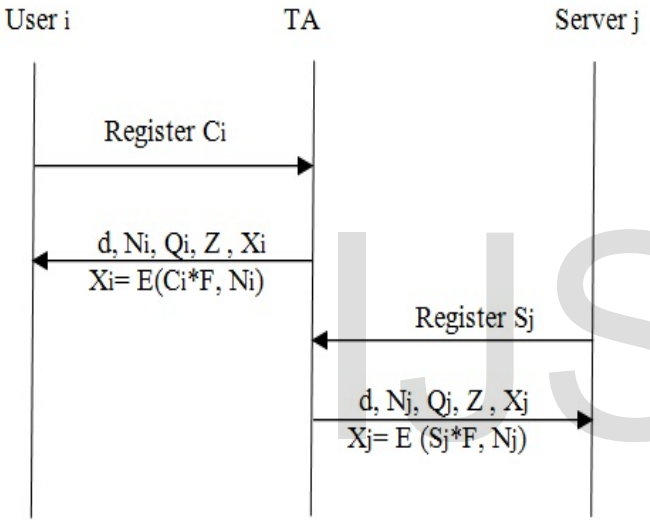


Fig. 6: the registration of user i and server j

4- Key agreement as shown in Fig. 7

User i generates a random number Mi and sends (Ci, Qi, d, Mi and Ri) to server j

Where Ri = E (Mi*F, Qi).

After server j receiving the message, it wills ensuring the signature of user i and TA match to the signature which stored on it (for user) and received in registration (for TA).

Ri = E (Mi*F, Qi) then F= D (Ri, Qi)/ Mi

If the signatures matched Server sends to user i the following parameters (Sj, d, Qj and Rj)

Where Rj = E (F, d)

After user i receives message

F= D (Rj, d)

User i ensuring the signature of TA match to the signature which received from server j.

If the two signatures matched user i start to sending messages to server.

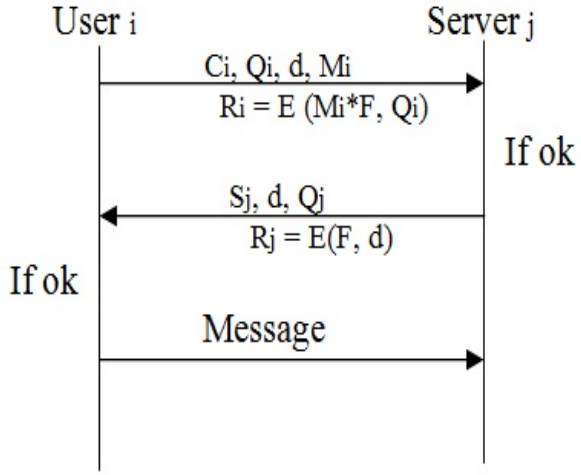


Fig. 7: Key agreement between user i and server j

- Trust Point

Fig.8 shows the trust point between user and server

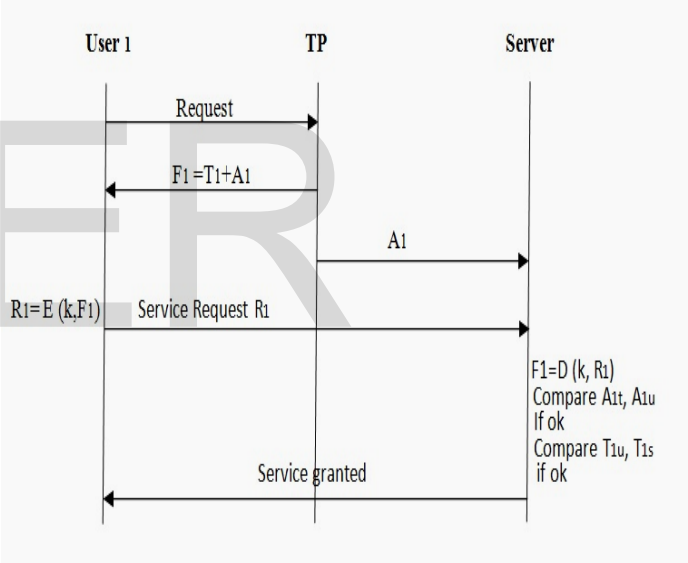


Fig. 8: Trust Point and Time.

Steps:

1. User 1 send request to Trust point, TP send F1to user 1 F1= T1+A1 and send A1 to server.
2. User 1 encrypt F1 and send R1 to server R1=E (K, F1).
3. After message reaching to server then server decrypt message
4. F1 =D (K, R1)
5. F1= T1+A1
6. Compare between A_{1t} and A_{1u} if equal, Compare between T_{1u} and T_{1s} if equal, Server send to user service granted.

Note that

- A_{1t} constant reach to server from TP.
- A_{1u} constant reach to server from user 1.

- T_{1u} time reach from user 1.
- T_{1s} time in server.

- TP in connecting between two devices.

Fig. 9 shows the trusted point between two devices

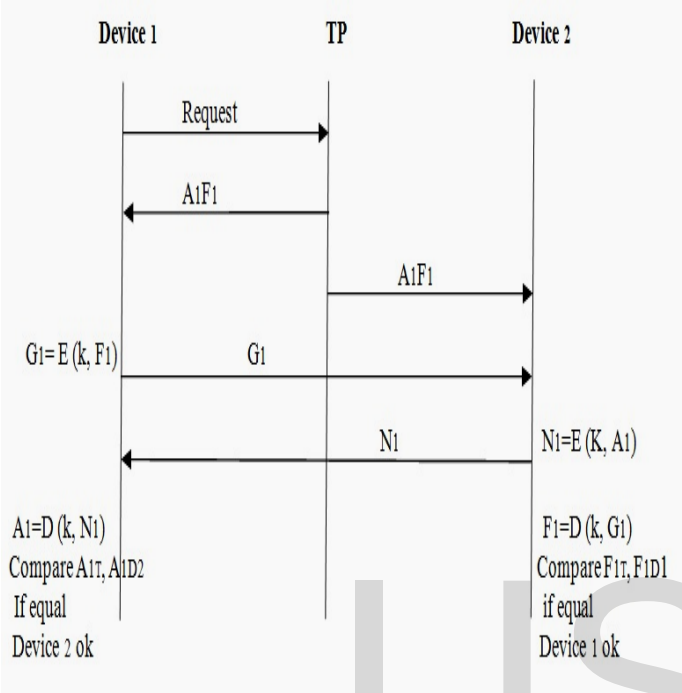
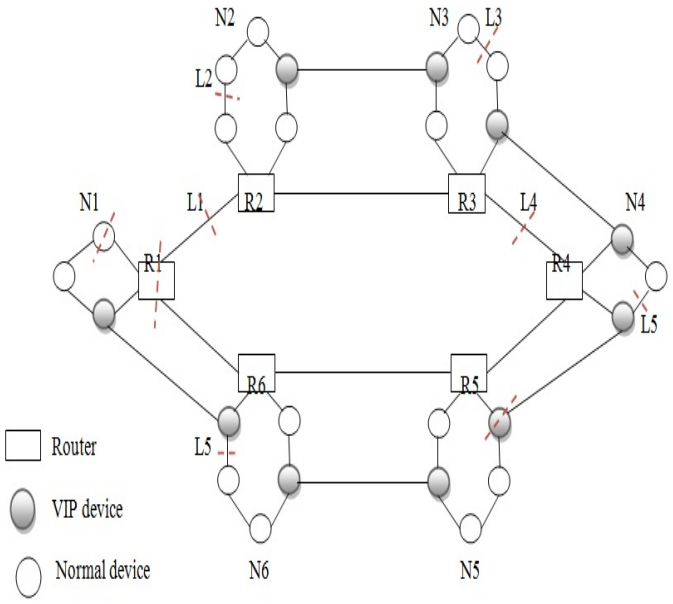


Fig. 9: Trust Point between two devices

Steps:

1. Device 1 sends request to trust point (TP), TP sends A1F1 to device1 and device 2.
2. Device 1 encrypts F1 and sends G1 to device 2, where G1= E (K, F1).
3. Device 2 encrypts A1 and send N1 to device 1, where N1=E (K, A1).
4. Device 1 compares A1t, A_{1D2}, if equal device 2 ok.
5. Device 2 compares F1t, F_{1D1}, if equal device 1 ok.



As shown in Fig. 10 six networks are connected using ring topology, if an attack happens on normal device in N1, other devices on network will not affected and risk factor will be 1, if an attack happens on L1, the risk factor will be zero because the two routers will connect to each other through the other routers, the same if an attack happens on any connection between devices or routers like (L2, L3, L4, L5 and L6) the risk factor will be zero. If an attack happens on router like R1, N1 will be connected through VIP devices to N6 and connect to the system

Fig. 10: Ring Topology, connecting VIP devices with two networks and using trust point

6 RESULTS

Table 3: Comparison between Virtual Bridge method [9], 2 routers method and VIP devices method, if network have 7 devices and 2 VIP devices

	RF on all devices	RF on VIP devices	Notes
Virtual Bridge	4	1 and depend on place of VIP devices in network	Number of devices which can connect with router will be decreased to N- VB devices and addresses of VB devices must not be repeated in the two networks.
2 Routers	0	0	Number of devices which can connect with router will be decreased to half and addresses must not be repeated in the two networks.
VIP devices	5	0	Number of devices which can connect with router will be N-1 and addresses of VIP devices must not be repeated in the two networks.
Optimal solution With TP and TAD	0	0	AS will be more robust against a lot of kinds DoS attacks

From Table 3, 2 Routers solution decreases number of devices which can connect with router will be to half and addresses must not be repeated in the two network. VIP devices solution decreases the risk factor in VIP devices to zero but number of devices which can connect with router will be N-1 and addresses of VIP devices must not be repeated in the two networks. Optimal solution with TP and TAD decreases the risk

factor to zero and AS in airports will be more robust against a lot of kinds DoS attacks.

6 Conclusion And Future Work

Protecting automation systems in airports from Dos attacks is a very important task, especially with the rapid growth in the way of attacks and the constant need for more security. AS in airports is faced with the challenge of extending or upgrading their Security Systems while maintaining a smooth operation method. This paper presented an overview of Dos attacks, detection and countermeasures in automation systems, giving proposed solutions to solve this problem and to decrease the risk factor to minimal by: 1- Connecting the network with two routers; the first router is the basic and the other router is reserve, 2- dividing the devices in airport to normal devices and VIP devices, connecting VIP devices with two networks, The optimal solution will use the advantages of the previous solutions , Trusted Authentication Device and Counter .
Otherwise, the Dos protection and detection measures must be updated and use a mix of all proposed solutions to achieve the minimal risk factor in AS.

Finally, the expected growth in the denial of service attacks in airports should be offset by significant growth in the protection measures.

Future steps:

1- Replacing old devices with smart devices in AS
2- The integration of intrusion detection mechanisms and DoS protection steps with smart devices in AS.

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