# Advanced Security

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## Motivation

- Increase of the exchanges over the Internet :
  - informations
  - commercial
- Changing work habits :
  - more communications
  - more mobility
  - more subcontractors.

Thus, less control on information

## General Overview

Lecturer : B. Martin

8 lectures, 8 exercises / labs
Goal : understand the operation mode + use of security tools for :

- a machine
- a LAN
- accessing the Internet

And the basic knowledge for understanding the tools :

- security basics
- cryptolography basics
- privacy
- web app ahcking
- your work

## Networking «Environment»

- Yesterday :
  - centralized
  - paper exchange
  - no remote access
- Today :
  - distributed, either on different sites or locally
  - remote access
  - subcontractors increase

More and more computer-dependant : IS become crucial. 98% of the companies admit an addiction from moderate to severe.

# Some values

| | |
|---|---|
| 2 to 10$ | price of valid credit card information depending upon the country |
| 5$ | price for renting 1h of botnet to conduct a DDOS |
| 2399$ | price of the *citadel* malware capable to intercept credit card information (and a monthly registration of 125$) |

Source : Cyberedu

# Network Threats

- message interception
  - passwords cracking
  - informations stealing
- systems intrusion
  - information stealing
  - viruses
  - malwares (mostly ransomwares)
  - embezzlement
- fake customers, fraud
- incidents

From the inside as well as from the outside

# Consequences

- communications increase, risks increase :
  - various frauds
  - hacking

# Risks

A simple equation :

Risk = Threat $\times$ Vulnerability [$\times$ Cost]

| | |
|---|---|
| Threat | circumstance/event with the potential to adversely impact organizational operations (including mission, functions, image, or reputation), organizational assets, or individuals through an information system via unauthorized access, destruction, disclosure, modification of information, and/or denial of service. Also, the potential for a threat-source to successfully exploit a particular information system vulnerability. |
| Vulnerability | Weakness in an information system, system security procedures, internal controls, or implementation that could be exploited or triggered by a threat source. |
| Cost | Financial impact |

# Main threats for 2020

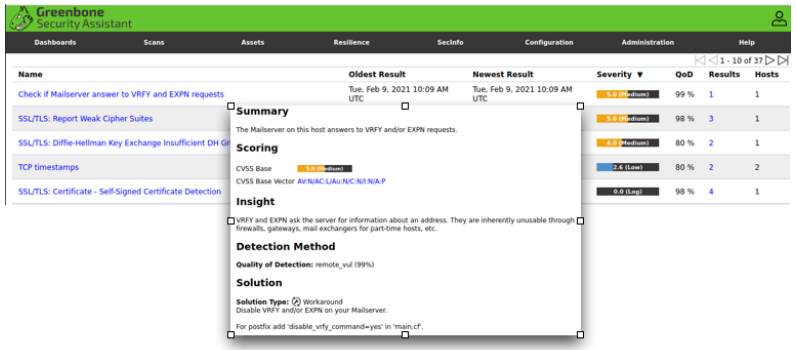
- DNS hijacking
- Cryptolockers
- Remote access Trojans
- O365 Phishing
- Digital Extortion Scams

See Cisco threat report

# Cost

- 800k€ : average cost of an attack
  - 330 k€ for a mid-sized company
  - 3.6 M€ for a big company
- 9 weeks to recover
- Advice : 5% of the budget for cybersecurity
- Try to evaluate the financial impact of every pair (threat, vulnerability)

# Vulnerabilities Assessment




If you know the vulnerabilities, you can determine the attack surface

# Risk Analysis

| Likelihood \ Severity | High | Moderate | Low |
|---|---|---|---|
| High | High | High | Moderate |
| Moderate | High | Moderate | Low |
| Low | Moderate | Low | Low |

- **High :** fix ASAP
- **Moderate :** fix in a reasonable delay
- **Low :** accept or mitigate the risk

Example : phishing

Study: 14% of the targets give credentials.
likehood : weak
severity : high
Decision : moderate risk

# Risk management

Consists of the realisation and keeping up to date :

- the **inventory** of the **assets**
- express the **security needs** of the assets
- risk analysis over the assets
- manage these risks to reduce them

Some methods : MEHARI or EBIOS (ISO 27001 related)
and educate staff (security letters, NDAs,...)

# Assets

Generally inventoried companies' assets :

96% physical assets (info/comm hardware)
93% software
82% information
57% info/comm services
41% staff and their knowledge
20% intangible value (reputation, image)

# Assets

Include the goods of the organization and its human resources ;
3 kinds :

- assets managed through the IS (infos and business processes)
- technical assets constituting the IS (hardware, software, appliance,...)
- environmental assets (people and building)

# Failures

58% design errors in the software or procedure
47% loss of essential service (energy, network,...)
46% usage errors
44% theft or disappearance
37% internal breakdown
36% viruses
8% natural disaster

# Cost of incidents

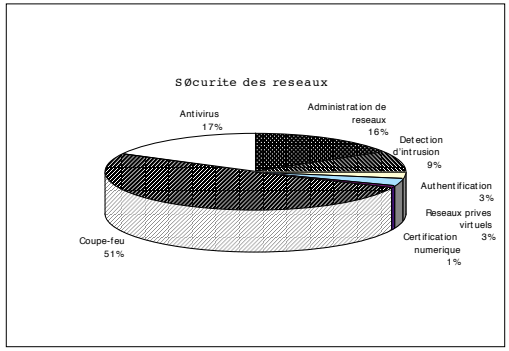
CLUSIF-APSAD (France) : statistics of incidents over 16 years :

| | Loss (M€) | | |
|---|---|---|---|
| Origin | 1984 | 1994 | 2000 |
| human Factor | 309 | 280 | 177 |
| Errors | 269 | 426 | 338 |
| Fraud | 335 | 998 | ? ? ? |

80% of losses are due to frauds from staff members.

# Some facts

IT expenses in the US (Source : Goldman Sachs)

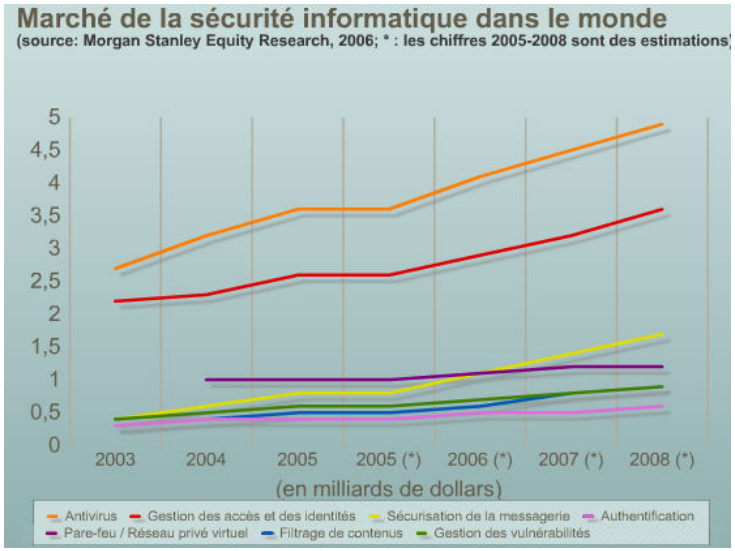



# Some facts

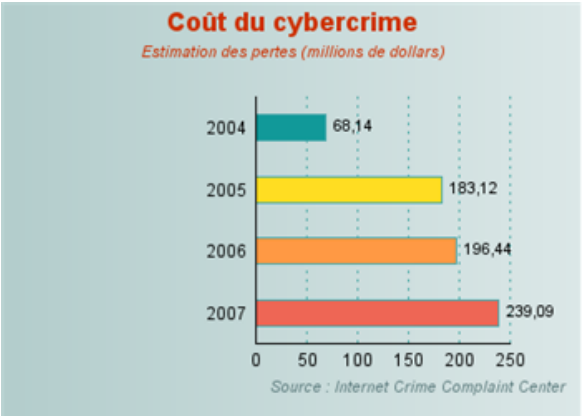
Faults Frequency vs financial impact

| Origin | Frequency | Financial Impact |
|---|---|---|
| Human Errors | 37% | 29% |
| Faults | 58% | 21% |
| Fraud | 5% | 50% |

# Some statistics



# Some statistics




327 billion € in 2014

# Two kinds of security

- **Data security :** concerns what is inside the computer (crypto+error correcting codes)
- **Network security :** concerns data when they are on the move between end systems.

# Goals of security

Increase the security in front of identified threats. Try to reach

- **disponibility :** the system is supposed to complete tasks within a certain time and with a certain QoS
- **integrity :** no information change by unauthorized people
- **confidentiality :** keep the information secret
- **authentication :** determine whether someone or something is, in fact, who or what it is declared to be

# OSI Standard (reminder)

Defines standards for data exchange

| | |
|---|---|
| 7 | application layer |
| 6 | presentation layer |
| 5 | session layer |
| 4 | transport layer |
| 3 | network layer |
| 2 | data link layer |
| 1 | physical layer |

# Outline


1. **Introduction**
2. **General concepts**
3. **Security auditing**
4. **Crypto components**


# Protect

- **Data :** informations kept inside the system ;
- **Ressources :** Systems (usually the computers) ;
- **Your reputation**

# 1. Introduction

- What do we need to protect
  - data
  - resources
  - reputation
- against whom ?
- how can we protect ?
- why ?

# Data protection

5 main characteristics :

- **Confidentiality :** The information shouldn't be available to an unauthorized user nor a process
- **Integrity :** information should not be modified nor destroyed by an unauthorized user
- **authentication :** determine whether someone or something is, in fact, who or what it is declared to be
- **Disponibility :** information has to be available to authorized users
- **Provability :** usage of logs

# Protect the resources

Each resource has a cost (HD, printer, CPU time) which shouldn't be accessed by an intruder.
A sys-engineer doesn't wish to re-install OSes if the systems have been altered or corrupted or used to hack other computers or systems.

# 1. Introduction

- What do we need to protect
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# Protect the reputation

**Why ?**
If your identity has been corrupted and the intruder commits evil actions under your name (legal problems. . . )
A site failure usually means that your organisation becomes untrusted.

# Typology of attacks

- **passive :**
  - unauthorized sniffing
  - unauthorized access to some information
- **active :**
  - unauthorized control of a computer
  - information change
  - acces to services
  - *DOS*

# Typology of attacks & risks

- **Intrusion :** any kind of (from the network, by a local terminal or by a program)
- **DOS :** attack against the availability of the systems. Classical consequence of viruses or *ping of death* like low orbit ion cannon
- **information theft :** it is not mandatory to penetrate a system to gain access to some information. A passive attack like sniffing may be sufficient (example : login).
- **ransoming :** a type of maltware designed to block access to a computer system until a sum of money is paid.

# Typology of attackers

- **Joyriders :** for fun
- **Vandales :** a will to damage by pleasure or for money
- **Score keepers :** intellectual challenge
- **Spies :** for the money (industrial secrets, economic intelligence)

# Who's sniffing or changing information ?

- governements :
  - NSA in the US
  - DGSE/DCRI in FR
- Mafia
- competitors
- hackers

# Physical attacks

Require a physical access to the installations (or close to)

- **interception :** gathering electromagnetic signal from a computer screen, sat or radio-frequencies listening
- **jamming :** DOS against the system.
- **sniffing :** gathering unencrypted information traveling in the network
- **scanning :** send a set of info to the system which provide a positive reply which is analyzed.
- **troyan :** the intruder attempts to introduce backdoors into the system.

# Logical Attacks

- **Disguise :** take ownership of someone else identity
- **Mystification :** simulate the behavior of another machine, site to gather information like login, etc
- **Replay :** variant of disguise allowing the attacker to gain access to a system by replaying a legitimate connection sequence
- **Substitution :** intercept the disconnection sequence of a legitimate user and substitute the identities
- **Saturation :** against the availability of a resource (HD or data link). aka *ping of death* or *NT chargen*
- **Troyan :** program containing a hidden functionality
- **Trapdoor :** hidden access point in a software put in place by its developer

# How to protect ?

- **No protection** add nothing to the basic installation process
- **Security by obscurity** hiding the system's existence for a small server or home computer which shouldn't interest a hacker
- **Host security** securing host by host. Good for several computers. Not scalable.
- **Network security** access control to the end systems instead of securing host by host. Requires firewalls, authentication and crypto.

# 1. Introduction

- What do we need to protect
  - data
  - resources
  - reputation
- against whom ?
- how can we protect ?
- why ?

# What to protect ?

Computer security covers

- **Physical aspect** : thefts, physical risks (electrical, fire, water...)
- **Logical aspect** : intrusions, logical bombs, viruses,...

avoid everything which provides a system failure or unavailability.

**The system's security is as good as its weakest component**

# 1. Introduction

- What do we need to protect
  - data
  - resources
  - reputation
- against whom ?
- how can we protect ?
- why ?

# 2. Concepts

- Security policy
- Security models
- Services and mechanisms

# Why ?

- IS have a cost : the hardware and software cost (CPU, HD, net. appliances, net components, subscriptions,...)
- informations have a cost : confidentiality ; their lost also has a value (human time for data recovering or system reconstruction, when possible)
- a major failure is usually fatal for a business company.
- systems are not isolated anymore and LANs become wider and wider

# Security policy

*Set of rules defining on what security applies*

- define the importance of the information which is stored in the system, how it is protected and which resources have to be accessed
- one policy by organism
- a security policy can cover secrecy, integrity or both
- every policy is set up by an authority
- domain : set of informations and resources which is covered by the same policy (sometimes realm)

# Security policy

**Goal :** inform users, staff and officers of the conditions to fulfill to protect the technological assets of the company.
It defines the mechanisms to protect and to audit the system against the identified threats.
Usually starts with the sentence :

*Everything which is not authorized is forbidden*

For more details, one can read RFC2196

# Characteristics of a security policy

1. it should be implementable
2. it should be improved by security measures and by sanctions
3. it must clearly state everyone's responsibility

# Who defines the security policy ?

All the staff must agree on the security policy for the security policy to become effective. It is more usually defined by

- the security officer
- the tech staff responsible
- the group in charge of auditing and security
- user representatives
- chief executive officer
- sometimes a lawyer

# Security policy contents

- purchasing policy for safety equipment
- a policy for respecting the individual rights (reading e-mails)
- access policy and data ownership with adequate error displays
- computer accounts management with audit
- authentication policy of the users
- define the resources availability, fault tolerance, OS and hardware updates and upgrades
- intrusions log

# Example of security policy

Secret data classification :

- every information has a security level
- everyone has a clearance level
- security level and clearance level consist in
  - a confidentiality level : (unclassified, confidential, secret, eyes only)
  - a set of domains (crypto, OTAN, NBC,. . . )
  - order relation :
    unclassified $<$ confidential $<$ secret $<$ eyes-only
    set of domain $A$ **dominates** set of domain $B$ if $B \subset A$.

# 2. Concepts

- Security policy
- Security models
- Services and mechanisms

# Example of security policy

- person $X$ has the right to read document $D$ if
  clearance($X$) $\geq$ confidentiality($D$) and
  set of domain($X$)$\supseteq$ set of domain($D$)

This policy doesn't cover information integrity.

# Security models

*Formal expression (math) of the security policy*
A security model contains :

- state variables (aka. subjects, objects, rights)
- transition functions

Goal : prove that every possible state of the system is coherent with a set of properties to fulfill.

# Security models

Security models for the secrecy :

- access control models ; control the access of subjects to objects
- information flow models. control data transmission between objects

Very few models take integrity into account
None take availability into account

# Access control by matrix (Bell-Lapaluda)

- **objects** : passive entities of the system
- **subjects** : active entities of the system which can access objects
- **access rights** : {owner, read, write, execute, join}
- **basic primitives** :
  - allow/deny a right
  - create/suppress a subject/object
- **transition rules** : if $S_i$ has right $D_j$ on $O_k$ then primitive$_l$

# Principles

- identity : is there a unique ID for each user, program, object or resource ?
- responsibility : are users responsible of their actions ?
- audit : is there a log of the user's actions ?
- authorizations : manage who has the right to do what.
- least privilege : what is the minimum necessary to complete a task ?
- sealing : different tasks should not interact
- redundancy : manage backups and redundancy, failure tolerance

# New generalization

ACL allow a better access control to files.
Generalize UNIX UGO method
Exists with BSD/WIN/OSX
AC defines the actions that a **role** can execute on a **resource**.
Role : user or group
Permissions : actions like read or write
Resource : file or directory
classical UNIX if Bob wants to allow Alice to gain access to A SINGLE file... how to proceed ?

# Types permissions

- On the file system : delete, readattr, writeattr, readextattr, writeextattr, readsecurity, chown
- on files : read, write, append, execute
- on directories : list, search, add_file, add_subdirectory, delete_child

`chmod +a ‘‘alice allow read’’ ./ressource.txt`

ACL executed before UNIX rights as an ordered set of rules

# Services and mechanisms

- Security policy is applied by means of security services
  provide a mean to implement the security policy
  Some services are useless for a given security policy :
  **Example** : advertising policy does not require secrecy.
- Each service fights again a particular set of threats
  **Example** : secrecy forbids unauthorized access to confidential data.
- Security services are implemented by security mechanisms
  some services may use the same mechanism
  **Example** : hash functions are used for both authentication and integrity.

# 2. Concepts

- Security policy
- Security models
- Services and mechanisms
  - Definitions
  - Security services
  - Security mechanisms

# Security services

Defined in ISO 7498-2 :

| | |
|---|---|
| 1 | Entity authentication |
| 2 | Access control |
| 3 | Data confidentiality with or without connection |
| 4 | Data integrity with or without recovery |
| 5 | non repudiation with proof of origin<br>non répudiation with proof of delivery |

# Authentification

- Entity authentication provides checking of a claimed identity at a point in time.
- Typically used at start of a connection.
- Addresses masquerade and replay threats.
- Origin authentication provides verification of source of data.
- Does not protect against duplication or modification of data.
- GSM, web servers

# Data confidentiality

- Protection against unauthorized disclosure of information.
- four types
  - Connection confidentiality
  - Connectionless confidentiality
  - Selective field confidentiality
  - Traffic flow confidentiality
- Internet banking session
- Encrypting routers as part of Swift funds transfer network

# Access control

- Provides protection against unauthorized use of resource, including :
  - use of a communications resource,
  - reading, writing or deletion of an information resource,
  - execution of a processing resource.
- Remote users

# Data integrity

- Provides protection against active threats to the validity of data
- 5 types :
  - Connection integrity with recovery
  - Connection integrity without recovery
  - Selective field connection integrity
  - Connectionless integrity
  - Selective field connectionless integrity.
- MD5 hashes (SHA-3)

# Non-repudiation

- Protects against a sender of data denying that data was sent (non-repudiation of origin).
- Protects against a receiver of data denying that data was received (non-repudiation of delivery).
- Analogous to signing a letter and sending recorded delivery

# 2. Concepts

- Security policy
- security models
- Services and mechanisms
  - Definitions
  - Security services
  - Security mechanisms

# Possible attribution of services by ISO layer

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| Authentication | | x | x | x | | | x |
| Access control Confidentiality | x | x | x | x | | x | x |
| selective confidentiality | | | | | | x | x |
| traffic secrecy | x | | x | | | | x |
| Integrity | | x | x | x | | | x |
| Non-repudiation | | | | | | | x |

# Security mechanisms

*Implement security services*

- enciphering
- digital signatures
- access control
- data integrity
- authentication mechanisms
- traffic packaging
- routing control
- trusted third party

- security management (key management)
- audit
- intrusion detection

# 3. Criteria for security evaluation

- Different criteria
- Orange book

# Orange Book

**Origine :** command from DoD US
**Utility :** system security evaluation

| | Description |
|---|---|
| A1 | like B3 but better security management |
| B3 | B2+ robustness against attacks |
| B2 | B1+ security policy, security level management, bonne auth. |
| B1 | C2+ manage security levels, data classification |
| C2 | C1+ improved login, audit, resources isolation (memory) |
| C1 | data protection based on the need to know. separation user/data |
| D | the rest |

# Different criteria

- *National Computer Security Center* (NCSC)
  - orange book : Trusted computer system evaluation criteria 1985
  - red book : Trusted network Interpretation of the TCSEC, 1987
- *European community*
  - Information Technology System Evaluation, 1991
  - comes from research on security models
  - important for the governments and defense
- *Bundesamt für Sicherheit in der Informationstechnik*
  - for firewalls
  - certification centers

# Orange Book

Based on Bell & Lapadula
hard and soft must satisfy some conditions for security policy, account management, insurance and documentation

- account management : identification, authentication, audit
- ensure that the system behaves accordingly to its specifications
- documentation on security functions, tests and design

# Orange Book

Proposes different security levels for the OSes with increasing security C1-C2-B1-B2-B3-A1
Example :

- A1 : SCOMP Honeywell
- B3 : Multics Honeywell, AIX IBM
- B2 : SunOS, AIX-IBM
- B1 : Solaris CMW, AIX IBM
- C2 : Solaris BSM, Solaris 2.3, IBM, DEC..

# Security Jobs

**1. Data protection officer**

Previous Next

A data protection officer (DPO) is a relatively new job role that is gaining in popularity following the implementation of the GDPR, the Europe-wide regulation that threatens businesses with tough fines if they fail to meet data compliance and reporting standards.

DPOs are most likely to be responsible for overseeing data protection strategies and ensuring on an ongoing basis that an organisation complies with all GDPR requirements.

According to Article 37 of the GDPR, the role is mandatory for all companies that collect or process EU citizens' personal data, hence the high demand since GDPR came into effect in May 2018.

Some of the responsibilities of a DPO may include training staff involved in data processing, being the point of contact between the company and GDPR supervisory authorities and interfacing with data subjects.

The average annual salary advertised for a DPO in the UK is £55,000.

# Contenu

Security Jobs

# Security Jobs

**2. Chief Security Officer**

Previous Next

Many CIOs know now that they cannot go at it alone when it comes to security, and so the demand for a chief security officer/chief information security officer (CSO/CISO) is increasing - especially with the explosion in data with IoT and ever-more sophisticated threats from attackers.

A CSO can be responsible for information security, corporate security or both. This may include the physical security of the organisation and its technologies, as well as its IT systems, people and processes.

CSO's are also expected to oversee all standards for hardware and data. They are expected to have knowledge of protecting the internal corporate systems as well as cloud services and managing third parties too.

The average annual salary advertised in the UK is £50,000.

# Security Jobs

well as

*l reporting by Hannah Williams.*

## ity analysts

Previous Next

Security Analysts

3/9

A security analyst will prepare, plan and carry out tests to ensure an organisation's network and system are able to protect itself against malicious attacks.

Security analysts are expected to protect the organisation the best they can either through consulting or carrying out system testing or combing over code.

They will be responsible for a range of activities including keeping up to date with the latest security and technology developments and planning disaster recovery in case of a data breach.

The average annual rate of pay advertised in the UK is £49,000.

# Security Jobs

## 4. Security consultants

Previous Next

Security Consultants

4/9

Security consultants aim to design security solutions depending on particular business needs.

Security consultants will have to think of every eventuality, ensuring that the best security software is in place.

Under the 'security consultant' umbrella, information security consultant was the most sought after role by UK businesses.

According to figures from Dice job market report 2017, consulting was one of the highest job areas amongst IT professionals with 16 percent working as a consultant.

In addition, there were 90 advertised job openings for network security consultants resulting in a growth of 120 percent over the past five years.

The average annual rate of pay advertised in the UK is £65,000.

# Security Jobs

## 5. Security engineers

Previous Next

Security Engineers

5/9

Security engineers focus on the design of security systems, ensuring that they are designed to block or react quickly to disruption such as cyber attacks or other malicious activities.

The security engineer title houses numerous job roles, including one of the most sought after by UK employers. Infrastructure engineers have undergone a massive growth period with demand for this role increasing by 617 percent over the past five years.

Network (security) engineers also received a boost in job openings with 590 job listings in each quarter over the last year with demand increasing by 139 percent in five years.

The average annual rate of pay advertised in the UK is £55,000.

**See also: How to get a job as a security engineer.**

# Security Jobs

## 6. Security managers

Previous Next

Security Managers

6/9

Security managers aim to provide secure procedures, from policy-led best practised to supervising security tests and software installations.

Over the past six years, security management positions have increased by 138 percent, with project management roles within the security management bracket increasing by 231 percent since 2011.

In terms of actual job advertisements, the role of information (security) manager was the most advertised, with 330 job openings during each quarter over the past year.

The average annual rate of pay advertised in the UK is £65,000.

# Security Jobs

## 7. Security architects

Previous Next

Security Architects

7/9

A security architect is responsible for updating and maintaining an organisation's security programs and/or infrastructure, as well as anticipating potential threats by keeping up to date with current trends.

The role of information security architect has increased by 269 percent over the past five years, with enterprise architect following a similar path with a reported growth of 137 percent since 2011.

The annual rate of pay advertised in the UK is £77,500.

# Security Jobs

## 8. Security officers and administrators

Previous Next

Security Officers & Administrators

8/9

An entry-level security officer will provide support for the security procedures and software in place and tackle its day to day running.

Over the past year, 150 information security officer jobs were advertised in each quarter.

The average annual rate of pay advertised in the UK is £45,000.