

# Introduction to Computer Security

## CS3235

Hugh Anderson

CS3235 - Hugh Anderson's notes.



### Contact information



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...and Spinellis...



## People



Dr Robert Deng, Institute for Infocomm Research

<http://www.i2r.a-star.edu.sg/icsd/staff/Robert/>



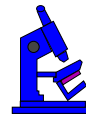
## Official SOC description



*With the widespread use of computers and Internet as well as electronic commerce, computer security becomes more and more important. The objective of this module is to give students basic knowledge of computer security. This module covers the following topics: threats to computer systems, network security fundamentals, security in a layered protocol architecture, authentication in computer systems, access control, intrusion detection, security architecture and frameworks, lower layers security protocols, upper layer security protocols, electronic mail and EDI security, directory systems security, Unix systems security, security evaluation criteria.*



## Assessment



Assessment	Weighting	Grade
Assignments		35%
Tutorials		5%
Mid-term	Closed book	10%
Final Exam	Open Book	50%
<b>Total marks</b>		<b>100%</b>



## Resources



- ✓ Computer Security: Art and Science, Matt Bishop
- ✓ The notes are expanded versions of the overheads
- ✓ Directed readings - all available on the Internet.
- ✓ IVLE at <http://ivle.nus.edu.sg/>
- ✓ Web site at <http://www.comp.nus.edu.sg/~cs3235>



## Comparison



- ✓ Different focus
- ✓ More introductory and practical material
- ✓ Less material duplicated



## Topics - general



- ✓ History and background,
- ✓ Preliminaries
- ✓ Encoding and decoding
- ✓ Protocols used for security.



## Topics - detail



- Mathematical, physical, legal (2 lectures)
- Security models (1 lecture)
- Secrecy (1 lecture)
- Insecurity (2 lectures)
- Safety/control hardware/software (2 lectures)
- Assurance (1 lecture)
- Protocols (1 lecture)
- + Case studies



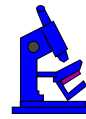
## Tutorials



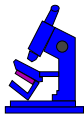
- ✓ Start in 3rd week
- ✓ More details next week



## My expectation...



- ✓ **Attend** classes and tutorials
- ✓ **Ask** if you don't know
- ✓ **Read** notes, book, and the readings...
- ✓ **Get interested** in the subject



## Chapter 1



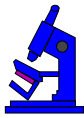
# Lecture 1 - Introduction



## Jump-about-introduction



...sorry sorry...



## The History of Herodotus



*For Histiaëus, when he was anxious to give Aristagoras orders to revolt, could find but one safe way, as the roads were guarded, of making his wishes known; which was by taking the trustiest of his slaves, shaving all the hair from off his head, and then pricking letters upon the skin, and waiting till the hair grew again. Thus accordingly he did; and as soon as ever the hair was grown, he despatched the man to Miletus, giving him no other message than this- "When thou art come to Miletus, bid Aristagoras shave thy head, and look thereon." Now the marks on the head, as I have already mentioned, were a command to revolt...*



## The History of Herodotus



- ✓ Histiaëus ensured *confidentiality*
- ✓ Used again by Germany in the 1914-1918 war
- ✓ This is now called *steganography*



## More history



- ✓ Cæsar encoded messages - *cryptography*
- ✓ Agreed *protocols* to ensure correct conduct of a war
- ✓ Examples taken from the world of warfare



## Aspects to “computer security”



Security problems in society reoccur in computers

- ✓ **Confidentiality** = locks/encoding.
- ✓ **Integrity** = handshakes/signatures

Computer versions much faster.

In this course, security includes wider aspects.



## Terms: Services

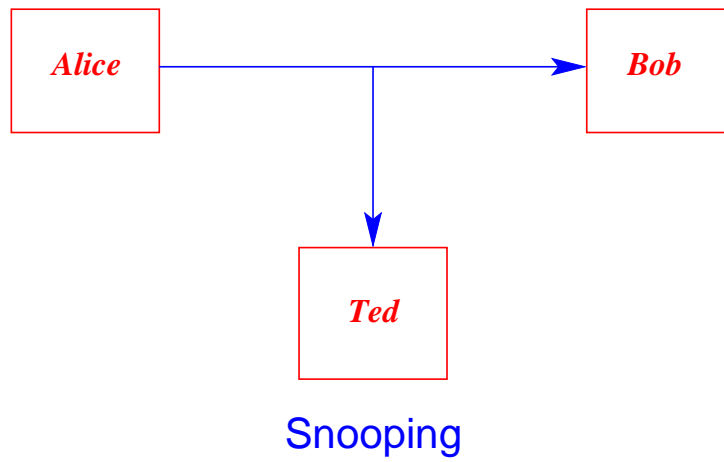


Three aspects of security *services*:

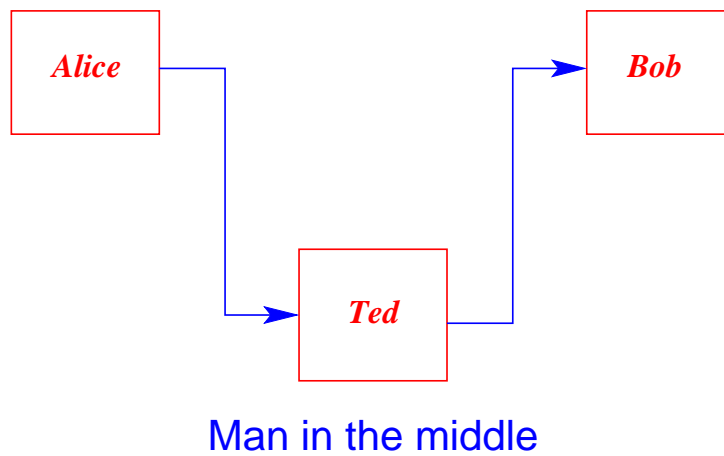
- **confidentiality**: concealing information - resources;
- **integrity**: trustworthiness of data - resources;
- **availability**: preventing denial-of-service.



## Terms: Threats

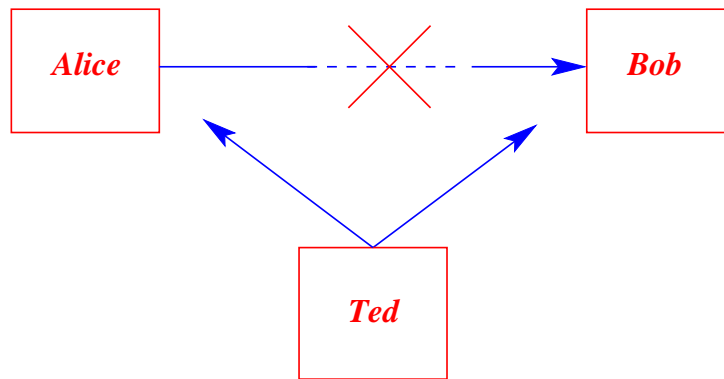


## Terms: Threats

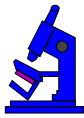




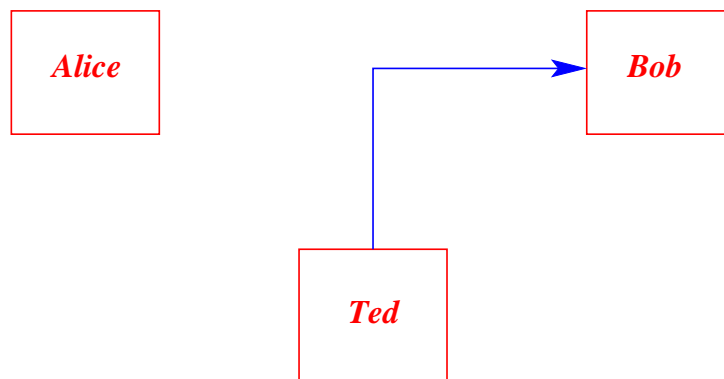
## Terms: Threats



Denial of service



## Terms: Threats



Spoofing



## Terms: Threats



- **disclosure**: unauthorized access (snooping);
- **deception**: accept false data (man-in-the-middle);
- **disruption**: prevent correct operation (denial-of-service);
- **usurpation**: unauthorized control (spoofing).



## Terms: Policy and mechanism



We differentiate between a security *policy* and a security *mechanism*:

- **policy**: what is allowed/disallowed;
- **mechanism**: ways of enforcing a policy



## NUS IT policy



For example, at NUS, we have an IT policy which includes a range of clauses regarding security concerns, such as:

### ***4.2 Undermining System Integrity***

*Users must not undermine the security of the IT Resources, for example, by cracking passwords or to modify or attempt to modify the files of other Users or software components of the IT Resources.*



## NUS mechanisms



### ***6.3 Use Of Security Scanning Systems***

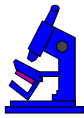
*Users consent to the University's use of scanning programs for security purposes at system level for computers and systems that are connected to the University's network. This is to ensure that any computers or systems attached to the network will not become a launching pad for security attack and jeopardise the IT Resources. System level scanning includes scanning for security vulnerabilities and virus detection on email attachments. Users' files and data are excluded from the scanning.*



## Topic: Preliminaries



- ✓ Review some mathematical concepts. [XOR](#), [modulo](#), [primes](#)
- ✓ The textbook, and my notes should be enough.
- ✓ *Physical* laws and procedures. [Information](#) and [Entropy](#)



## Topic: Security models



These models provide [formal](#) ways of looking at computer security in an [abstract](#) manner.

1. [Define](#) a model, and
2. [prove](#) it secure
3. Ensure system [complies](#) with model

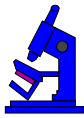


## Topic: Security models



- The **Bell-LaPadula** model (no read-up, no write-down) provides a military viewpoint to assure *confidentiality* services.
- The **Biba** and **Clark-Wilson** models attempt to model the trustworthiness of data and programs, providing assurance for *integrity* services.

... Read ahead ...



## Topic: Security models



- ✓ Determine **properties** of the model, and
- ✓ **Verify** that implementations are valid.
- ✓ Basis of **trusted operating systems**
- ✓ Modelling for **availability** is tricky



## Topic: Secrecy



- ✓ Commerce relies on **secure transfer** of information, and
- ✓ Often just want things to be **secret**
- ✓ Distance between you and an **attacker** is shrinking
- ✓ Criminals have an **access** point into your living room



## 2000 years ago...



Replace each Roman letter in a message, with another Roman letter, obtained by rotating the alphabet some number of characters:

I	C	L	A	V	D	I	V	S														
A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R	S	T	V	X	Y	Z
V	X	Y	Z	A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R	S	T
E	Y	G	V	Q	Z	E	Q	O														

We can specify a Cæsar cipher by just noting the number of characters that the alphabet is rotated.



# 60 years ago...

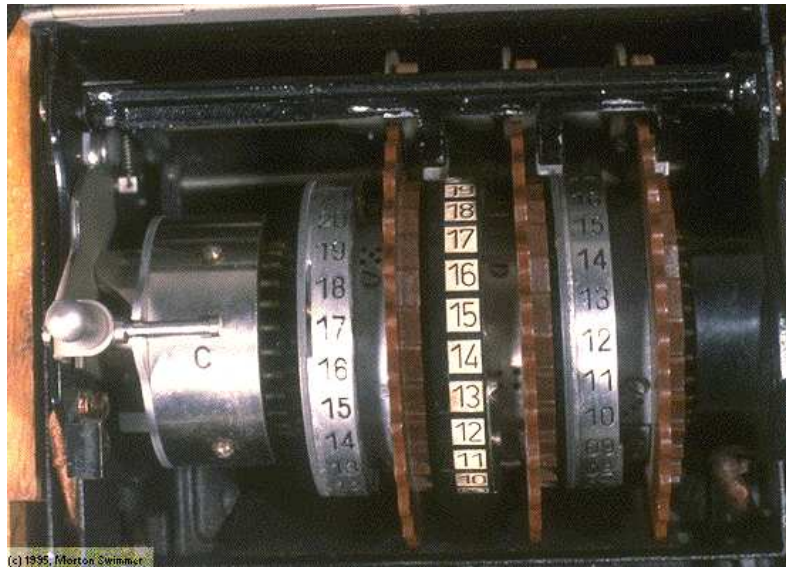


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# 60 years ago



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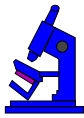
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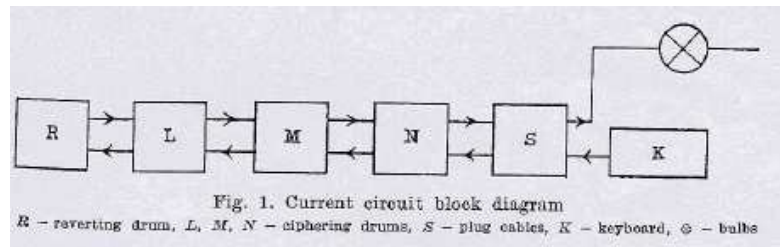
# Enigma machines



- ✓ Commercial device
- ✓ Used by the German military
- ✓ Belief that could not be decoded.

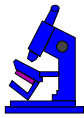
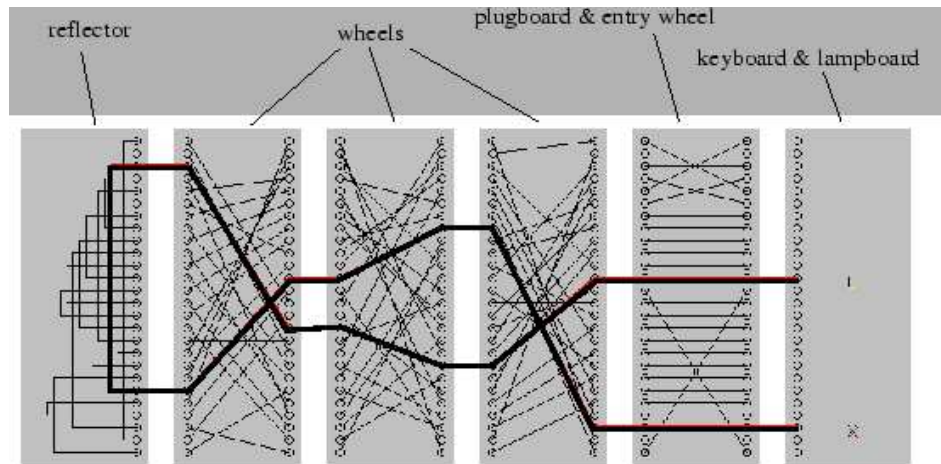


# Enigma machines





# Enigma machines



# Hacking Enigma



- ✘ Americans captured a German submarine?
- ✘ Alan Turing did it all?
- ✘ Hard workers at Bletchley Park?
- ✘ My dad?



## Hacking Enigma



- ✓ 1928: Poles intercepted a machine
- ✓ 1928: Maths Dept at University of Poznan: Marian Rejewski, Jerzy Rozycki, Henryk Zygalski.
- ✓ Decoded some messages
- ✓ German army using an extra level of encoding
- ✓ French spies uncovered the extra encoding



## Hacking Enigma



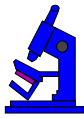
- ✓ 1933-1939: the Polish Ciphers Office was able to decode messages, although slowly.
- ✓ July 1939: Poland gave Enigma copies to English
- ✓ Bletchley Park
- ✓ May 1941: English captured the U-110 submarine, complete with a genuine Enigma machine, and code books.



## Hacking Enigma



- ✓ 1941-45: English could decode most German military transmissions.
- ✓ 1941-45: developed a hardware system
- ✓ Precursor to modern-day computers



## Today...sssshhhh



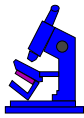
- ✓ Secure encrypted communications between
  - ✓ two untrusted hosts
  - ✓ over an insecure network.
- ✓ Other connections can also be forwarded
- ✓ Users must prove their identity to the remote machine



## Secure-shell



- ✓ Based on public-key cryptography:
  - ✓ Encryption and decryption use separate keys
  - ✓ not possible to derive one from other
  - ✓ RSA is one such system.
- ✓ Encodings believed to be difficult to decode, and
- ✓ protocols of message exchange that are believed to be secure.



## Topic: Insecurity



- ✓ Systems dangerously easy to subvert
- ✓ Adversary gains control over your system
- ✓ You sign a contract, and other party doesn't.
- ✓ Investigate hacking and reducing risk



## Topic: Insecurity



A locked air-conditioned room with file server:

- The lock can be picked, or the door kicked in.
- The console of the server computer may be password protected, but
  - it may be rebooted with a different disk.



## Topic: Insecurity



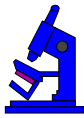
- The reboot process may be (BIOS) password protected, but
  - the case of the computer may be opened and the disk removed.
- And so on...



## Topic: Insecurity



- ✓ Tempest - computer screen monitoring
- ✓ Paper
  - ✓ <http://jya.com/emr.pdf>
- ✓ Overcoming
  - ✓ [http://www.cs.rice.edu/~dwallach/courses/comp527\\_s2000/ih98-tempest.pdf](http://www.cs.rice.edu/~dwallach/courses/comp527_s2000/ih98-tempest.pdf)
- ✓ Monitor screens at a distance of 1km for \$15.



## Topic: Insecurity



```
hmap run completed -- 1 IP address (1 host up) scanned
# sshnuke 10.2.2.2 -rootpw="210HD101"
Connecting to 10.2.2.2:ssh ... successful,
Attempting to exploit SSHv1 CRC32 ... successful,
Resetting root password to "210HD101",
System open: Access Level (9)
# ssh 10.2.2.2 -l root
root@10.2.2.2's password: |
```



Kick in doors without even using your feet

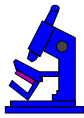


## Topic: Insecurity



Non-repudiation for e-commerce:

- the buyer cannot order an item and then deny the order took place;
- the seller cannot accept money or an order and then later deny that this took place.



## Topic: Insecurity



- ✓ Intrusive hacking is common on the Internet.
- ✓ Farms of subservient machines:

*At first, it looked as if some students at the Flint Hill School, a prep academy in Oakton, Va., had found a lucrative alternative to an after-school job...*



## Topic: Insecurity



- ✓ Virusses: boot-sector hide their code in the boot sector of a disk.
  - ✓ the stoned virus for DOS, written by a student from New Zealand!
- ✓ A virus contains code that replicates, attaching itself to a program, boot sector or document. Some viruses do damage as well.



## Topic: Insecurity



Worm is a program that makes copies of itself, transferring itself around. The Morris worm in 1988:

*On the evening of 2 November 1988, someone infected the Internet with a worm program. That program exploited flaws in utility programs in systems based on BSD-derived versions of UNIX. The flaws allowed the program to break into those machines and copy itself, thus infecting those systems.*



## The Morris Worm



*This program eventually spread to thousands of machines, and disrupted normal activities and Internet connectivity for many days.*

<ftp://ftp.cs.purdue.edu/pub/reports/TR823.PS.Z>

The author of the worm, Robert Morris, was convicted and fined \$10,050 in 1990, and is currently a professor in the Parallel and Distributed Operating Systems group at MIT, lecturing in distributed systems areas.



## Topic: Protocols



Some aspects of security are determined by the way in which we do things (the protocol), rather than what is actually done.



## Topic: Protocols



## Summary of topics

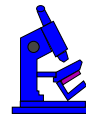


In this section, we introduced the following topics:

- An introduction to computer security
- Some definitions



## Further study



- Textbook Chapter 1
- Monitoring computer screens  
<http://jya.com/emr.pdf>
- Overcoming Tempest monitoring  
[http://www.cs.rice.edu/~dwallach/courses/comp527\\_s2000/ih98-tempest.pdf](http://www.cs.rice.edu/~dwallach/courses/comp527_s2000/ih98-tempest.pdf)
- The Morris worm  
<ftp://ftp.cs.purdue.edu/pub/reports/TR823.PS.Z>
- Military mathematical modelling of security  
<http://80-ieeeexplore.ieee.org.libproxy1.nus.edu.sg/xpl/tocresult.jsp?isNumber=13172>