Master

Embedded Systems and Computer Security

ISAE

Rodolphe Ortalo
CARSAT Midi-Pyrénées
(rodolphe.ortalo@free.fr)
rodolphe.ortalo@carsat-mp.fr
http://rodolphe.ortalo.free.fr/ssi.html

Overall presentation (1/2)

- Fast paced computer security walkthrough
  - Security properties
  - Attacks categories
  - Elements of cryptography
  - Introduction to mandatory security policies
- Embedded systems and security
  - Specificities
  - Physical attacks (SPA, DPA)
  - TPM
- Software development and security
  - Security requirements and process
  - Static verification and software development tools
  - Common criteria / ISO 15408

Overall presentation (2/2)

- Case studies
  - Wireless networks
  - New generation avionics systems
  - Network appliances
  - Mobile telephony
  - Gaming devices

- Wrap-up (if time permits)
  - IDS
  - Firewalls
  - Tripwire
  - Metasploit
  - Anti-virus

Overall presentation (1/2)

- **Fast paced computer security walkthrough**
  - Security properties
  - Attacks categories
  - Elements of cryptography
  - Introduction to mandatory security policies
- Embedded systems and security
  - Specificities
  - Physical attacks (SPA, DPA)
  - TPM
- Software development and security
  - Security requirements and process
  - Static verification and software development tools
  - Common criteria / ISO 15408

A wide perimeter

- Non-technical activities
  - Agents habilitation
  - Written delegation
  - Contracts
  - Security awareness
  - Teaching
- Protection
  - Network
  - System
  - Applications
- Monitoring
  - Intrusion detection
  - General monitoring
- Threats awareness
  - Attacks
  - Vulnerabilities / Audit
  - Intrusion testing
- Risk management and risk evaluation

Overall presentation (1/2)

- Fast paced computer security walkthrough
  - **Security properties**
  - Attacks categories
  - Elements of cryptography
  - Introduction to mandatory security policies
- Embedded systems and security
  - Specificities
  - Physical attacks (SPA, DPA)
  - TPM
- Software development and security
  - Security requirements and process
  - Static verification and software development tools
  - Common criteria / ISO 15408

Basic properties - **Confidentiality**

- Property of information not to be revealed to non-authorized users
  - prevent users from reading confidential data, unless they are authorized
  - prevent authorized users from communicating confidential data to non-authorized users

Basic properties - **Integrity**

- Property of information to be accurate
  - prevent inadequate alteration (creation or destruction) of data (either incorrect or performed by non-authorized users)
  - no user should be able to prevent a legitimate modification

Basic properties - **Availability**

- Property of information to be accessible when it is needed
  - allow access to authorized users for reading or writing
  - no user should be able to prevent authorized users from accessing information

What is information?

- Data
  - typed, generated, stored, transmitted, displayed, etc.
- «Meta-data » : associated to other data and accessed by computing processes
  - identities, names, adresses (user, computer, process, peripherals, etc.)
  - time (date of computation)
  - access rights
  - etc.

Other properties

- Anonymity = confidentiality of user identity
- Privacy = confidentiality of (personal data + user identity)
- Message authenticity = integrity of (content + sender identity + date + …)
- Document authenticity= intégrité of (content + creator identity + date + …)
- User authenticity = integrity of identity
- « Auditability » = availability of (who, what, when, where, …) of an action
- Sender non-repudiation = availability of (sender identity + …) + integrity of content
- Receiver non-repudiation = availability of (receiver identity + …) + integrity of content
- Intellectual property protection = confidentiality of content (+ integrity of container)

Overall presentation (1/2)

- Fast paced computer security walkthrough
  - Security properties
  - **Attacks categories**
  - Elements of cryptography
  - Introduction to mandatory security policies
- Embedded systems and security
  - Specificities
  - Physical attacks (SPA, DPA)
  - TPM
- Software development and security
  - Security requirements and process
  - Static verification and software development tools
  - Common criteria / ISO 15408

Attackers and their motivations

- Game : exploration (to the limits), extend and apply knowledge, find new weaknesses, improve security : "hackers" ("pirates" = "crackers")
- Emulation, sectarism : group of hackers : "exploits"
- Vandalism : strengh demonstration, punish : "web defacing", virus, worms…
- Political, ideological : ex. CCC
- Vengeance
- Profit : espionnage, funds extorsion : unfair concurrency, organized crime
- Cyber war, terrorism?
- Awareness raising, lobbying
- Abusive protection : ex. SONY

Various attack classes

- Passive sniffing
- Interception
- Covert channels
- Cryptanalysis
- Repudiation
- Inference
- Masquerading
- Trapdoors
- Logical bomb
- Trojan
- Virus
- Worm
- Denial of service
- and complex attacks...

Buffer overflows

- Buffer overflows are a notorious problem
- Many exploits are based on them
- They are very easily introduced by simple programming mistakes

- BTW, very nice reference for *applied* secure programming
  - http://www.openbsd.org/papers/

Most C examples taken or adapted from
“Puffy at Work”, Henning Brauer, Sven Dehmlow

Buffer overflow

- What happens when a function is called (in C)?
  - General registers are saved on the stack
  - The CPU return address is computed and saved on the stack
  - Function arguments are stored too
  - The local variables of the function are also stored in the CPU stack

- Details are hardware dependent, but the overall idea is the same

Exemple

- A function

```
void function(char *str) {
char buffer[16];
strcpy(buffer,str);
}
```

- A buffer overflow

```
int main(void) {
char *s = "Soy demasiado largo
para este espacio.";
function(s);
}
```

Impact ?

- Program behavior is unpredictable
- Write to unexpected stack sections
- Can we overwrite the return address?
- With carefully chosen values, it is possible to enforce where the CPU execution returns at the end of the function
- This could be in code under our control, if we manage to inject it somewhere in memory (e.g. on the stack itself)

Not always that obvious

```
void function(int a, int b, int c) {
  char buffer1[8];
  char buffer2[16];
  int *ret;
  ret = buffer1 + GAP_TO_PC_ON_STACK;
  (*ret) += WIDTH_OF_1_CINSTRUCTION;
}

void main() {
  int x;
  x = 0;
  function(1,2,3);
  x = 1;
  printf("%d\n",x);
}
```

Not always that obvious

- GAP_TO_PC_ON_STACK and WIDTH_OF_1_CINSTRUCTION depend on the environment
  - e.g. : i386 linux 2.4 with gcc 2.95:12, 8
- This program prints 0 NOT 1
  - Possibly some kernel insult too
- Might be very interesting to overjump a line
  - Especially if there is a call to an authentication function or access control on that line

Prevent buffer overflows

- Be careful writing to buffers
  - Length check is mandatory
- Never do any tricks in C that you do not understand
  - *Never do any tricks in C*
- strcpy and strcat are forbidden
  - use strlcpy and strlcat (*if available*)

Format strings

```
int function(char *user) {
  fprintf(stdout, user);
}
```

- Problem: what if `user` is `"%s%s%s%s%s%s"`

- Most likely: program crash
- If not, program will print memory content

How does it work ?

- printf is called as a function
- functions get their arguments passed on the stack
- each format directive in a format string usually has a corresponding argument passed along
- for interpreting format directives, printf walks up the stack, expecting the right arguments to be there ; but, if they do not...

- Better :

```
int function(char *user) {
  fprintf(stdout, "%s", user);
}
```

Affected functions

- Any function using a format string
- Printing
  - printf, fprintf, *sprintf,* snprintf, asprintf
  - vprintf, vfprintf, *vsprintf*, vsnprintf, vasprintf
- Logging
  - syslog, err, warn

SQL Injection

- Building the query naively

```
statement = "SELECT * FROM users WHERE name = '"+
 userName+"' AND pwd = '"+userPassword+"' ;"
```

- What if
  - userName is « `' OR '1'='1'; -- '` »
    - userPassword is not a problem anymore
  - userName is « `' OR '1'='1'; DROP TABLES; -- '` »
    - The application is not a problem anymore either

- Mitigation
  - Prepared statements (+ parse + execute)

```
SELECT * FROM users WHERE name = ? and pwd = ?;
```

  - External libraries (for auth. or SGDB mapping)
  - Parsing or escaping (**not** recommended)

SEL/**/ECT

- Obfuscation techniques are frequently used
- Sample ideas (for SQL injection)
  - Abuse of white space or comments
  - Fragmentation of the injected query
  - HTTP parameters
  - Comments (impl. specific ones, special comments)
  - Unprobed areas in packets
- Possible lessons
  - A full parser for parameter validation
  - Intrusion detection is not so easy

- NB: Numerous examples of code encryption or signature among attackers

Overall presentation (1/2)

- Fast paced computer security walkthrough
  - Security properties
  - Attacks categories
  - **Elements of cryptography**
  - Introduction to mandatory security policies
- Embedded systems and security
  - Specificities
  - Physical attacks (SPA, DPA)
  - TPM
- Software development and security
  - Security requirements and process
  - Static verification and software development tools
  - Common criteria / ISO 15408

Terminology

- Cryptology = cryptography + cryptanalysis
  - Cryptography (κρυπτος = hidden) : messages non understandable by third parties
  - Cryptanalysis : discover secret(s), decypher

- Not to be confused with steganography (στεγανος = covert) → invisible ink
  watermark

- Cypher, encryption, decryption, clear (text), cryptogram

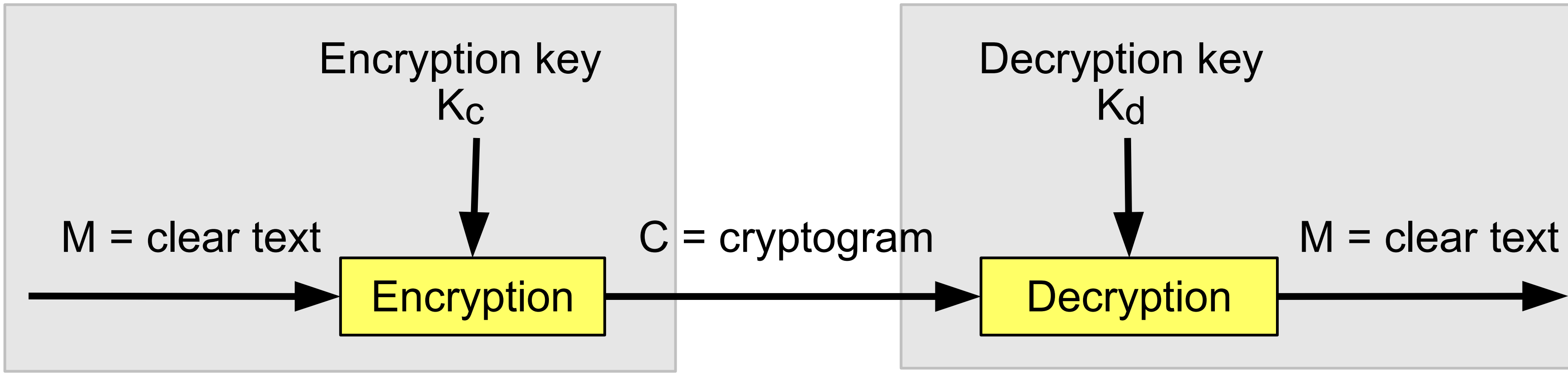
Preamble (1/2)

- A domain of mathematics which exhibits some of the most significant advances of the end of 20th century, but
  - Mathematical proofs (of strength) are rare
  - Ciphers do break
  - Implementations do break too
  - Few experts (possibly few knowledgeable people)
- Difficult and counter-intuitive
  - example: encrypting twice can be dangerous

Preamble (2/2)

- Recent and unverifiable release of military control over cryptology
- Theroetical issues combine with implementation difficulties
  - examples : random number generators, key generation, key protection, empty space padding, etc.
  - also at the level of hardware implementation

Encryption (confidentiality)



- Notation encryption $C = \{M\}_{Kc}$
  decryption $M = [C]_{Kd}$
- Confidentiality
  - Without knowing Kd, it must be « impossible » to find M
  - It must be « impossible » to find Kd, even knowing C and M (« (known) clear text » attack)
  - It must be « impossible » to find Kd, even knowing C while choosing M (« chosen clear text » attack)

Symetric ciphers $K_c = K_d$ (= K)

- All known ciphers until 1976 !

- Examples
  - DES (1976)
    - 56 bits key (+8 parity bits)
    - 64 bits blocks
  - AES (2002)
    - keys of 128, 192 or 256 bits
    - 128 bits blocks

DES : Data Encryption Standard (1975)

- Story
  - Base from IBM. With improvements from NSA.
  - The first algorithm scrutinized by NSA to become public... thanks to the standardization body.
- 64 bits blocks. Key of 56 bits + 8 bits (ex.: parity)
- Design oriented towards hardware implementation
- 3DES : common (generic) improvement
  - 112 bits key
- Huge public cryptology efforts associated to DES
- Feistel cipher family
- Lots of variants (ex.: *key-dependent S-boxes*)

AES : Advanced Encryption Standard (2001)

- Story
  - Selected by NIST from 15 proposals over a 5 year public selection process
  - Originally called Rijndael.
- 128 bits blocks. Keysize of 128, 192 or 256 bits
- Fast in both software and hardware
- Still resistant to open attacks (after a decade)
- Substitution-permutation network family
- Algebraic representation over GF(2^8)
- Now **very** wide adoption
  - AES-NI instruction set (Intel/AMD)
  - Common in most of encrypted flows nowadays

Symetric ciphers modes of operation

$M = M_1 \cdot M_2 \cdot \ldots \cdot M_n$ $\quad$ $C = C_1 \cdot C_2 \cdot \ldots \cdot C_n$

- ECB – *Electronic Codebook*
  - $C_i = \{M_i\}_K$
  - $M_i = [C_i]_K$
- CBC – *Cipher Block Chaining*
  - $C_i = \{M_i \oplus C_{i-1}\}_K$
  - $M_i = C_{i-1} \oplus [C_i]_K$
  - IV sort of M_0
- Stream ciphers
  - CFB – Cipher Feedback Mode
  - OFB – Output Feedback Mode

Public key ciphers $K_c \neq K_d$

- Knowing Kc, it must be «impossible» to find Kd
  - Kd is private (one must know Kd to decrypt)
  - Kc is public (everyone can encrypt): notion of public keys directory
- Ex.: RSA (1976)
  - (Probably) based on the (big) numbers prime factorization problem

  $e \cdot d \equiv 1 \bmod((p-1)(q-1))$ $K_c = \{pq, e\}$ $K_d = \{p, q, d\}$
- Ex.: El Gamal (1985)
  - Based on the discrete logarithm computation problem in finite fields
  - $y = g^x \bmod p$ $K_c = \{x\}$ $K_d = \{y, g, p\}$

One-time pad : perfect cipher

- The key is a serie of random bits as long as the message and the algorithm is exclusive-or
  - $C_i = \{M_i\}_{K_i} = M_i \oplus K_i$
  - $M_i = [C_i]_{K_i} = C_i \oplus K_i$
- According to information theory (Shannon), this is a perfect cipher (the key must **never** be reused)
  - Not very convenient
  - Possible

exclusive-or : brown paper bag cipher

- $C = M \oplus K$ et $M = C \oplus K$
- *No* security
  - Compute $C \oplus C_{\gg k}$ with $k = \{ 1, 2, ... \}$ and count identical bytes. The coincidence indice indicates the key length n (in bytes).
  - $C \oplus C_{\gg n} = M \oplus M_{\gg n}$ removes the key.
  - Find the clear text using intrinsic redundancy of the original message (1,3 bit of information per byte in ASCII english for example).
  - Few minutes cryptanalysis.

NB: Vigenère polyalphabetical cipher (1523-1596)

Strengths of symetric ciphers

- Speed
  - ~1 Gb/s in hardware
  - ~100 Mb/s in software
- « Short » keys
  - 80 bits typically to withstand brute force attacks (today)
- Convenient to encrypt personal files (no need to share a key)

Weaknesses of symetric ciphers

- To communicate, the secret key must be shared
  - sender and receiver have to trust each other, and both carefully protect the secret key
- How to distribute or renew the key?
  - Encrypt the new session key with the old one
  - Encrypt the session key with a device-specific key ⇒ trusted keys repository (directory)
  - Use a public key algorithm (Diffie-Hellmann)
  - Quantum cryptography
  - Avian carrier

Strengths of public key ciphers

- No trust needed between sender and receiver
- « Easy » key management
  - Public directory of public keys or peer to peer exchange
  - The private key must « never » be sent
- Allow for new kind of usage : symetric keys distribution, electronic signature, certificates, etc.

Symetric keys agreement

- Example : Alice generates a random (symetric) session key K and encrypt it with the public key of Bob

- Exemple : Diffie-Hellmann

  Alice randomly generates :

  n : big prime number with $(n\text{-}1)/2$ prime
  and chooses g = generator of a subgroup q de n
  (typically, $g = 2$, $q = (n\text{-}1)/2$)

  x (Alice's secret key) is such as $\log_g n < x < q$

  1. Alice computes $K_a = g^x \bmod n$ and sends (n, g, K_a) to Bob.
  2. Bob randomly generates y (Bob(s secret key),
     computes $K_b = g^y \bmod n$, and sends K_b to Alice.
  3. Alice and Bob now each compute a session key separately
     $K = K_b^x \bmod n = K_a^y \bmod n = g^{xy} \bmod n$

Weaknesses of public key ciphers

- Complex computation
  - slow (∼1 Mb/s)
  - long keys (1024 or 2048 bits),
    except with elliptic curves (∼160 bits)

- Specific problems
  - Integrity of public keys directory
  - Keys lifetime
  - Revocation
  - Private key sharing necessity?
  - Algorithms limitations : e.g. encrypt a small M with RSA

Hash functions → fingerprint

- « One-way hash function » H
  - Fingerprint or hash H(M) has a fixed width n (e.g.: 128 bits) whatever the length of M
  - The probability that 2 different messages M et M' have the same fingerprint H(M)=H(M') is $\sim 1/2^n$
  - Knowing M, it is easy to compute H(M)
  - Knowing M, it must be impossible to find $M' \neq M$ with H(M') = H(M)
- Examples: MD5, SHA-1, SHA-256, DES in CBC mode
- Typically, one slices M in blocks $m_1, m_2, ..., m_k$
  $h_1=F(cte,m_1)$, $h_2 = F(h_1,m_2)$, ..., $h_k = F(h_{k-1},m_k) = H(M)$

Application : integrity

- Networking : against man-in-the-middle send message and fingerprint through distinct channels
- Files : modification detection
  - Examples : Tripwire, Samhain
  - On a trusted host, compute the fingerprints of stable files (OS, configuration, main programs, ...) and keep them in protected storage
  - Regularly or in case of doubt, recompute fingerprints to check them (with a trusted computer)

Crypto. up&down example

- 2004
  - Collision classes found in MD5
  - Extrapolation opportunities to SHA-1
- 2005
  - MD5 considered untrusted
  - Theoretical doubts with SHA-1 (numerous collisions)
- 2006, 2007, 2008
  - Rumors around SHA-1
- 2007 - 2012
  - NIST public competition for SHA-3
  - Five SHA-3 finalists since 2010-12-09
    - BLAKE, Grøstl, JH, Keccak and Skein
  - SHA-3 selected in 2012 (Keccak)

Julius. Caesar
Via Appia 1
Rome, The Roman Empire

May, 22, 2005

To Whom it May Concern:

Alice Falbala fulfilled all the requirements of the Roman Empire intern position. She was excellent at translating roman into her gaul native language, learned very rapidly, and worked with considerable independence and confidence.

Her basic work habits such as punctuality, interpersonal deportment, communication skills, and completing assigned and self-determined goals were all excellent.

I recommend Alice for challenging positions in which creativity, reliability, and language skills are required.

I highly recommend hiring her. If you'd like to discuss her attributes in more detail, please don't hesitate to contact me.

Sincerely,

Julius Caesar

Julius. Caesar
Via Appia 1
Rome, The Roman Empire

May, 22, 2005

Order:

Alice Falbala is given full access to all confidential and secret information about GAUL.

Sincerely,

Julius Caesar

http://www.cits.rub.de/**MD5Collisions**/

```
ortalo@hurricane:~/$ md5sum letter_of_rec.ps order.ps
a25f7f0b29ee0b3968c860738533a4b9  letter_of_rec.ps
a25f7f0b29ee0b3968c860738533a4b9  order.ps
ortalo@hurricane:~/$
```

RSA+AES+SHA3

- The ideal combination or the minimum baseline for computer security ?

Use crypto. correctly

Use proven code instead of rewriting, do not reinvent the wheel (or the brakes)

- Nintendo Wii
  - Used strncmp() instead of memcmp() to compare the SHA hash

- Works well when one feeds it a signature that starts with null bytes

- Strings in C are null terminated
- A null byte is only 256/2 random attempts away on average

Other topics (undetailed)

- Steganography
- *Watermarking*
- Random generators
- Prime generation
- Key escrow
- Voting
- Timestamping
- Destruction
- Protocols
- Cryptanalysis

Overall presentation (1/2)

- Fast paced computer security walkthrough
  - Security properties
  - Attacks categories
  - Elements of cryptography
  - **Introduction to mandatory security policies**
- Embedded systems and security
  - Specificities
  - Physical attacks (SPA, DPA)
  - TPM
- Software development and security
  - Security requirements and process
  - Static verification and software development tools
  - Common criteria / ISO 15408

Security policy and security model

- The security policy
  - « *specifies the set of laws, rules and practices that regulate how sensitive information and other resources are managed, protected and distributed within a specific system.* » [ITSEC, 1991]
  - physical, personnel or procedural, logical
- A security model
  - Formal description or mathematical abstraction
- Classical partition between model entities
  - active: subjects *s*
  - passive: objects *o*

Discretionary and mandatory policies

- Descretionary policy
  - each object *o* is associated to a specific subject *s*, its owner who manipulates access rights at his descretion
  - the owner can freely define and grant such access rights to himself or another user
- Mandatory policy
  - discretionary rules (access rights)
  - *and* : mandatory rules (habilitation level)

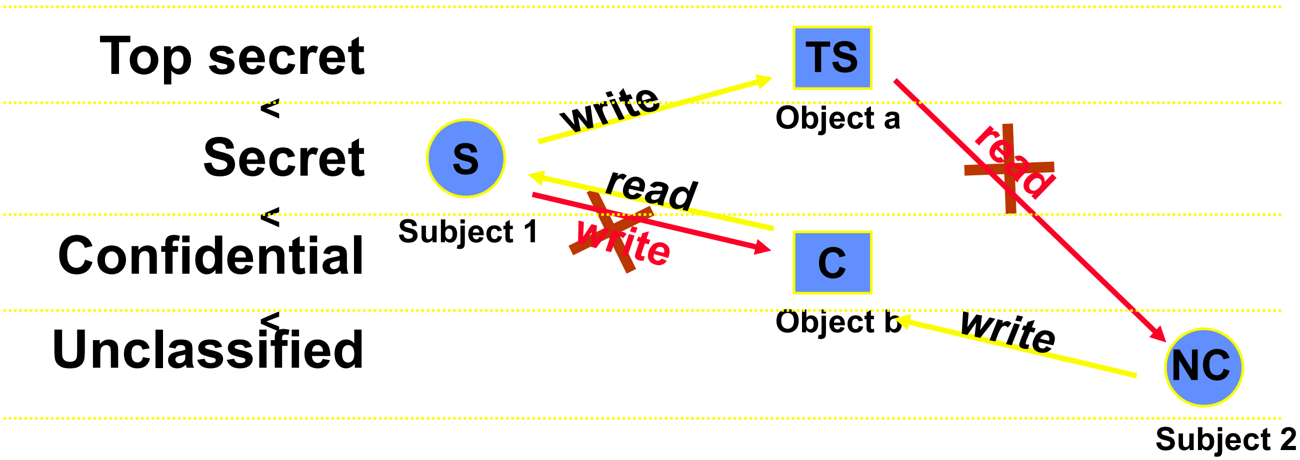
Access control matrix model

[Lampson 1971]

- State machine : state = (S,O,M)
  - O set of objects
  - S set of subjects ($S \subseteq O$)
  - $M(s,o)$ is the set of rights that subject s holds over object o
  - rights belong to a finite set A

Multilevel mandatory policy of Bell-LaPadula (1975)

- (habilitation) level of subjects *h(s)*
- (classification) level of objects *c(o)*
- prevents information flow from an object to a lower level object
- prevent any subject from gaining information from an object which level is higher than their habilitation



Bell-LaPadula Model

- classification *cl* : totally ordered set
- compartment *C* : set of categories
- $n=(cl,C)$, $n'=(cl',C')$: $n \leq n' \Leftrightarrow cl \leq cl'$ et $C \subseteq C'$ (treillis)
- simple property

$$\forall s \in S,\ \forall o \in O,\ \text{read} \in M(s,o) \Rightarrow c(o) \leq h(s)$$

- ⋆-property

$$\forall s \in S,\ \forall (o,o') \in O^2,\ \text{read} \in M(s,o) \wedge \text{write} \in M(s,o') \Rightarrow c(o) \leq c(o')$$

Other policies and models

- Non-interference
- Non inference
- HRU
- Clark-Wilson
- Chinese wall
- RBAC
- etc.

... for further studies.

Weaknesses of BLP and Biba

- Weaknesses
  - Overclassification degrades (security) information continuously (or out-of-model declassification procedures are introduced)
  - The model does not represent all information flows and does not take into account covert channels
- Biba (integrity) policy
  - dual of BLP for integrity assurance
  - rights = { write, read, invoke }
  - similar weakness : information integrity level degrades continuously

Policy, protection and access control

- Security rules are enforced via security mechanisms (hardware or software)
- Easy to imagine for rules like « it is permitted to... » or « it is forbidden that... » – protection mechanisms – privileged instructions, memory access control, file access control, etc.
  - ➞ authorization
- Harder for rules like « it is mandatory that... » or « it is recommended that... »
  - ➞ action triggers, ressource management

Overall presentation (1/2)

- Fast paced computer security walkthrough
  - Security properties
  - Attacks categories
  - Elements of cryptography
  - Introduction to mandatory security policies
- **Embedded systems and security**
  - **Specificities**
  - Physical attacks (SPA, DPA)
  - TPM
- Software development and security
  - Security requirements and process
  - Static verification and software development tools
  - Common criteria / ISO 15408

Embedded systems characterization

- Various designation (different real cases)
  - real-time
  - critical
  - embedded (in a vehicle)

  - autonomous / distant from the power plug
  - hidden / distant from any user
  - distributed (communicating?)
  - integrated (in a hardware platform)

  - other? : lost, stolen, fallen from the shelf (re-purposed...), numerous&similar?
- Up to now, not so different from a regular computer (esp. from the security point of view)

Inventory attempt

- smart cards
- switches/routers
- game consoles
- GPS receivers
- ADSL+TV boxes
- mobile phones
- digital video recorders
- home automation?
- (industrial) robots
- energy meters
- RAID cards
- coprocessors
- chronotachygraph (?)
- (artificial) satellites
- rockets
- automatic pilots
  VAL, train?
- switch/firewall AFDX
  (avionics)
- cars?

Domains of application

- Industry
  - Industry automation and robotics
  - Energy (smart grid)
- Vehicles
  - Avionic domain
  - Space domain
  - Ground-transport domain
- Consumer electronics
  - mobile telephony
  - video games
  - Internet acces (high speed)
  - media broadcasting

Multiple security requirements

- Supplier/content protection
  - GSM phone
  - Media distribution
- ES environment protection
  - The vehicle itself, its passengers
  - Vehicle ressources (e.g. satellite)
- ES owner protection
- ES self protection
  - smart card, cryptographic chipset
- And the protection of an embedded *information system*, *i.e.* several networked ES

Evolution

from

- Some security functionalities

to

- Security management at the system design and architectural level (both hardware and software)

Security of industrial systems is getting a lot of attention recently (and then?)

Motivations for evolution

- Widening attack range
  - logical, physical, auxiliary channel
- Limited computing resources
  - especially wrt. computational needs (crypto.)
- Limited ressources in general
  - especially energy (storage also)
- A need of modularity/flexibility
  - fast moving components and standards
- Multiple different security functionalities expected by users

Challenges

- complexity
  - embedded software gets more and more complex
  - efficient languages (C, C++) are not specifically secure
- extensibility
  - Java, .NET: designed for extension
  - J2ME, JavaCard too
  - dynamic updates (with code execution)
  - mise à jour (exécution) dynamique
- networking
  - WiFi, bluetooth
  - Internet

Note : Nothing really specific to embedded systems...

Overall presentation (1/2)

- Fast paced computer security walkthrough
  - Security properties
  - Attacks categories
  - Elements of cryptography
  - Introduction to mandatory security policies
- Embedded systems and security
  - Specificities
  - **Physical attacks (SPA, DPA)**
  - TPM
- Software development and security
  - Security requirements and process
  - Static verification and software development tools
  - Common criteria / ISO 15408

Physical attacks

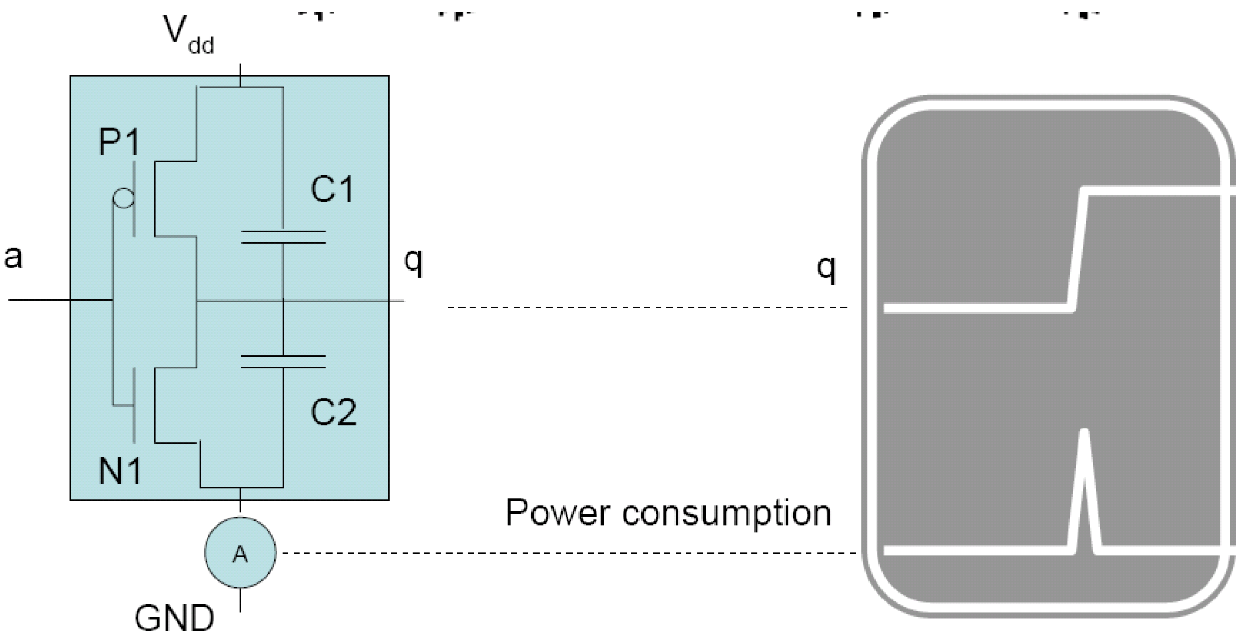
- Direct hardware attack
  - micro-probing
  - substrate reconstruction
  - debugging interface access (JTAG, etc.)
- Difficulties
  - Costly (with respect to other attacks)
  - Destructive
  - Alternative attack precursor
- Primary target: cryptographic chipsets

Auxiliary channels

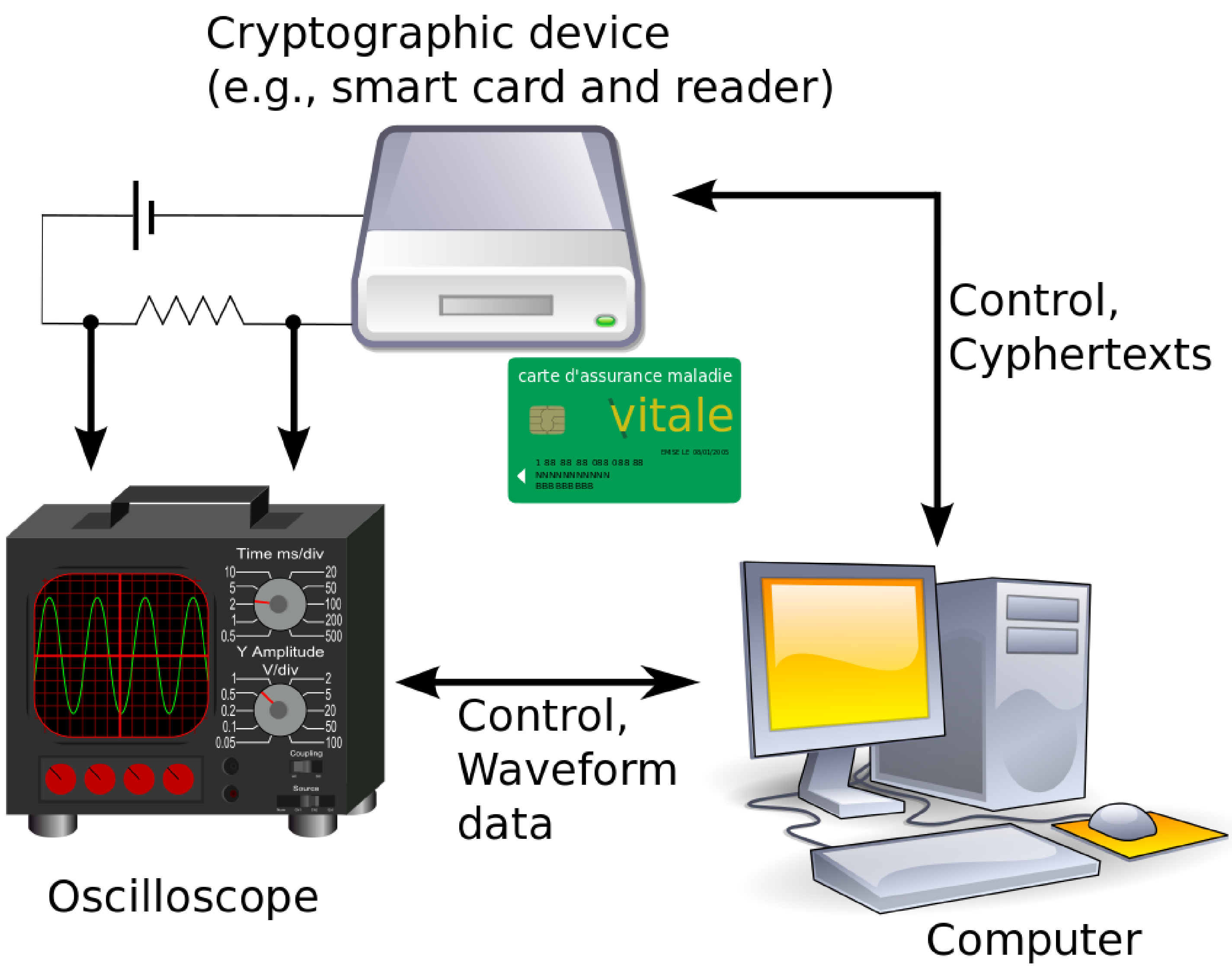
- Timing (temporal) analysis
- Power analysis
  - SPA: simple power analysis
  - DPA: differential power analysis
- Impact
  - Find correlation between measurements and secret keys
  - Very efficient (D*XX*)
  - costly counter-measures
    - rigourous, counter-intuitive, patented

Power analysis

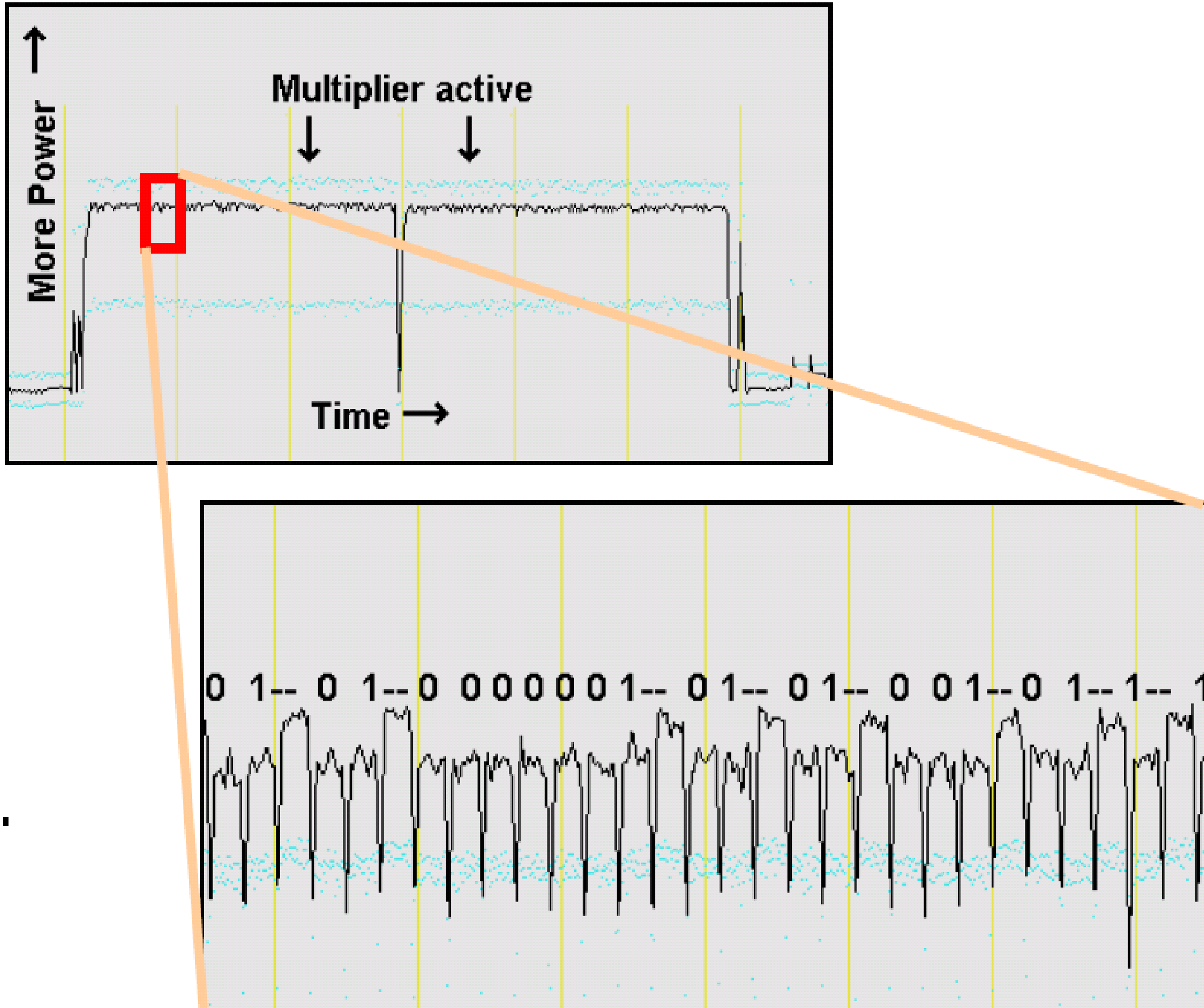
- References (most pictures reused)
  Elisabeth Oswald (Univ. Bristol) - dpabook.org
  Josh Jaffe & P.Kocher (*timing analysis*)
  (Cryptography Research, Inc.)



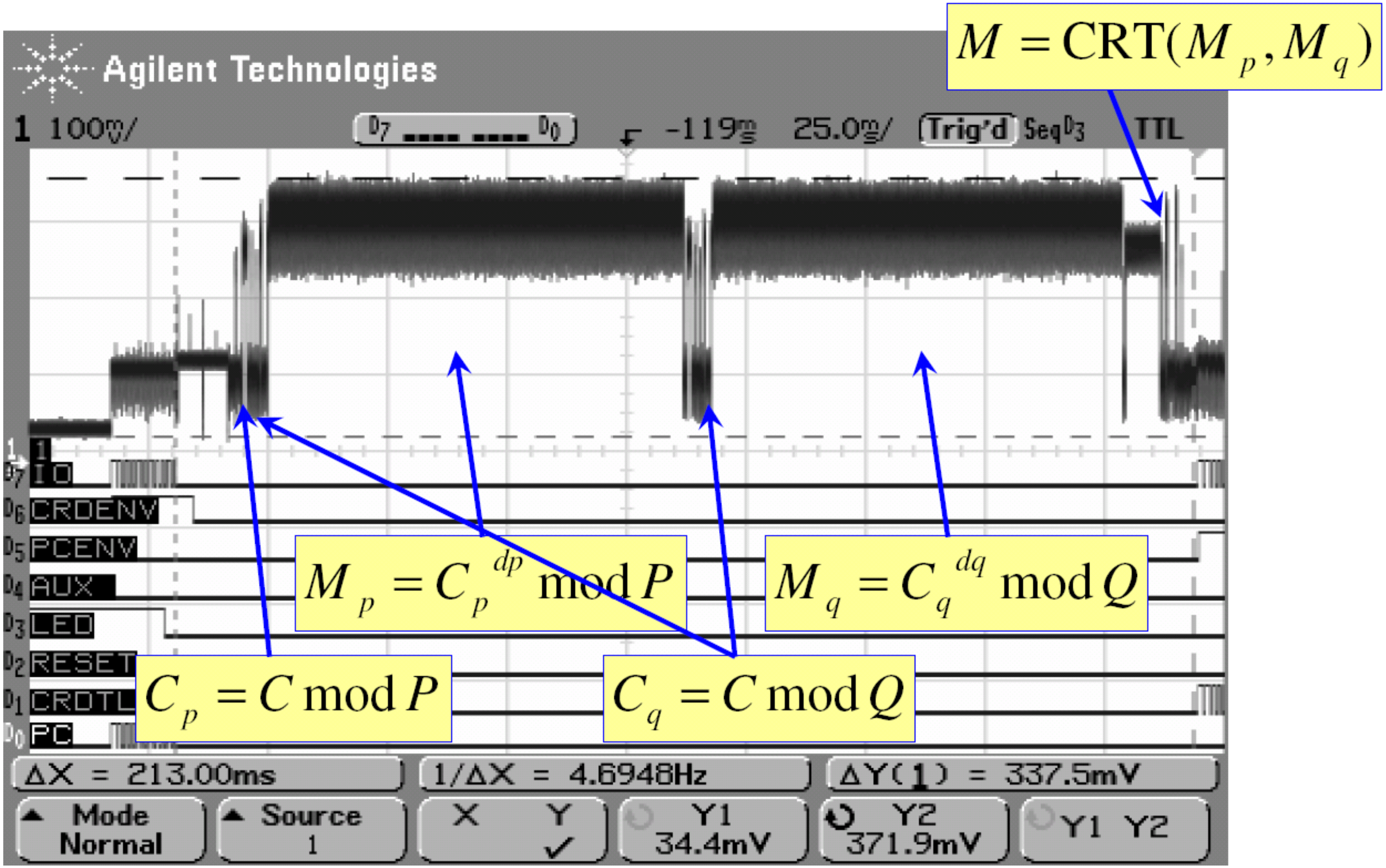
Power analysis typical setup



SPA Example


Multiplier active
More Power
Time
0 1-- 0 1-- 0 0 0 0 0 0 1-- 0 1-- 0 1-- 0 0 1-- 0 1-- 1-- 1

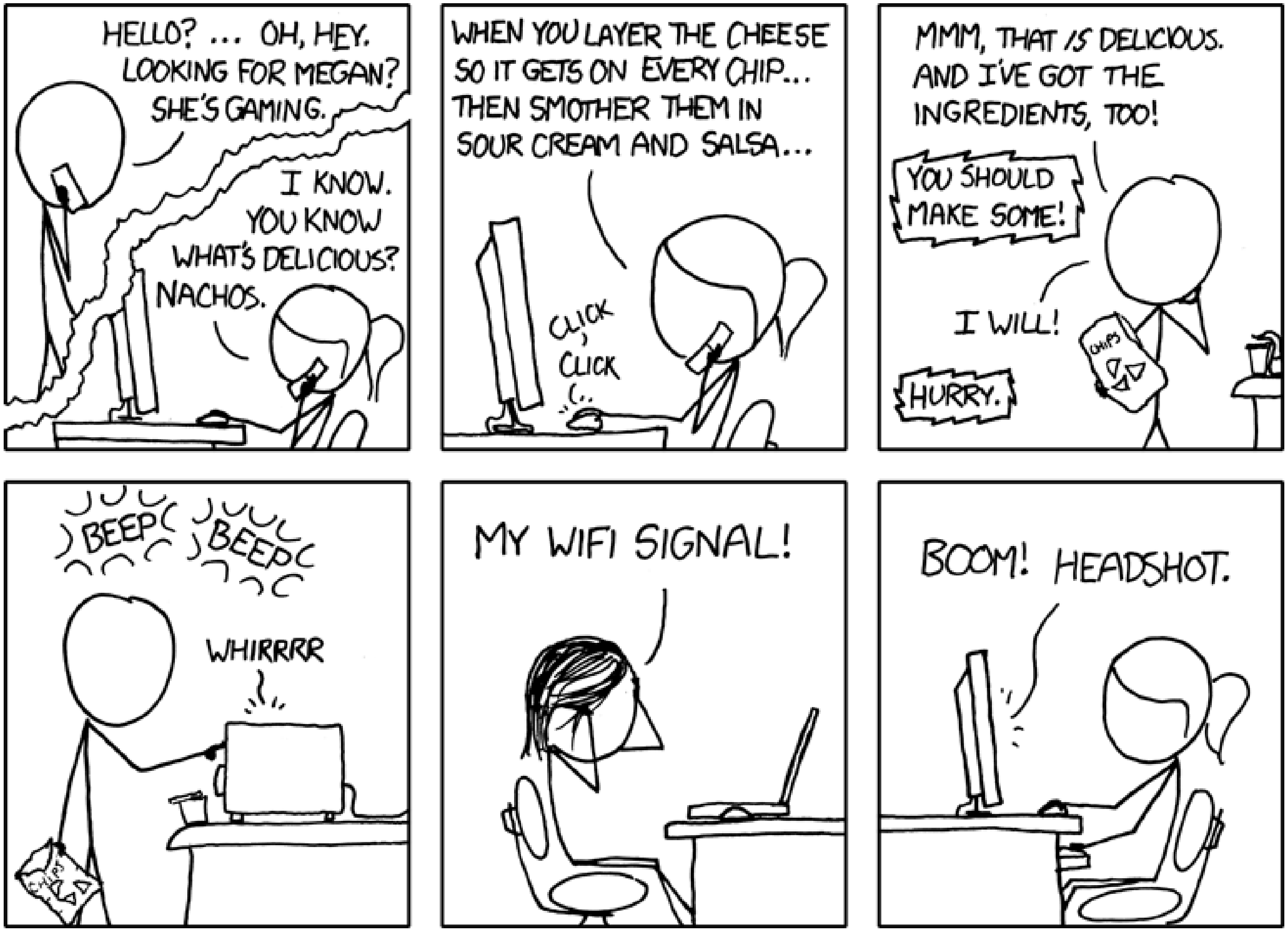
SPA Example


Agilent Technologies
1 100mV/
-119mV
25.0ms/
Trig'd
TTL
IO
CRDENV
PCENV
AUX
LED
RESET
CRDTL
PC
ΔX = 213.00ms
1/ΔX = 4.6948Hz
ΔY(1) = 337.5mV
Mode
Normal
Source
1
X
Y
Y1
34.4mV
Y2
371.9mV
Y1 Y2
$M = \mathrm{CRT}(M_p, M_q)$
$M_p = C_p^{dp} \bmod P$
$M_q = C_q^{dq} \bmod Q$
$C_p = C \bmod P$
$C_q = C \bmod Q$

Alternative attacks

- DPA
  - Differential power analysis
  - Much less sensitive to noise disruptions
- Fault injection
  - induce normal behavior perturbation
  - may allow deduction of secret information
- EMA
  - electromagnetic analysis
  - best of *eighties* (TEMPEST protection)
  - remastered

NACHOS - https://xkcd.com/654/



Physical protection

- Secure computing
  - hardware
  - software
  - hybrid

- Attack resistance
  - Trusted Computing
    - e.g.: TPM (TCPA)

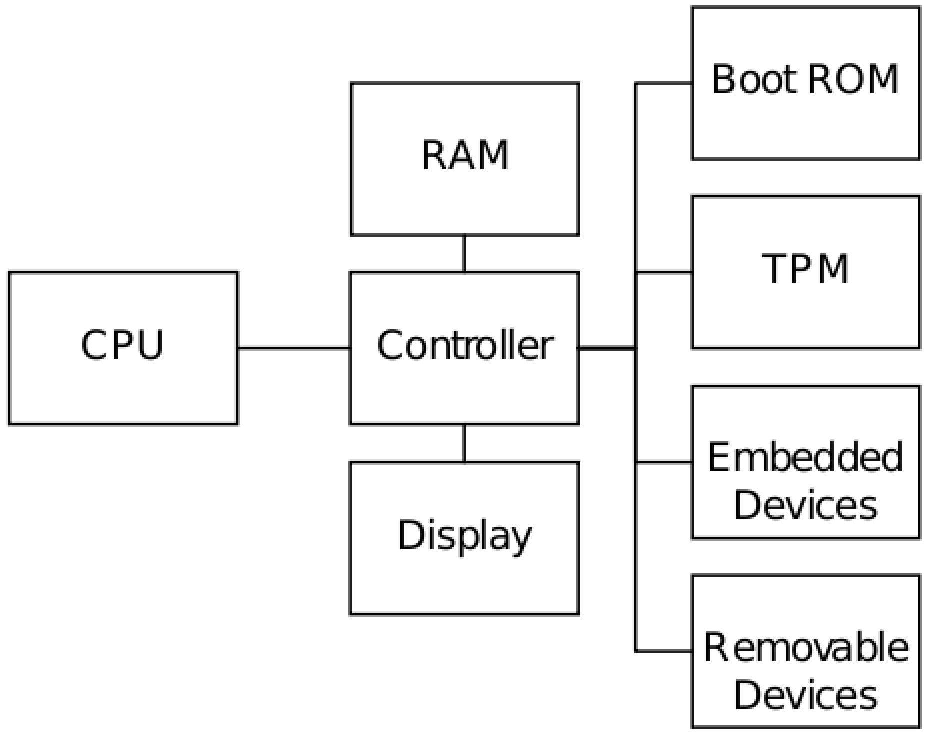
Overall presentation (1/2)

- Fast paced computer security walkthrough
  - Security properties
  - Attacks categories
  - Elements of cryptography
  - Introduction to mandatory security policies
- Embedded systems and security
  - Specificities
  - Physical attacks (SPA, DPA)
  - **TPM**
- Software development and security
  - Security requirements and process
  - Static verification and software development tools
  - Common criteria / ISO 15408

TPM

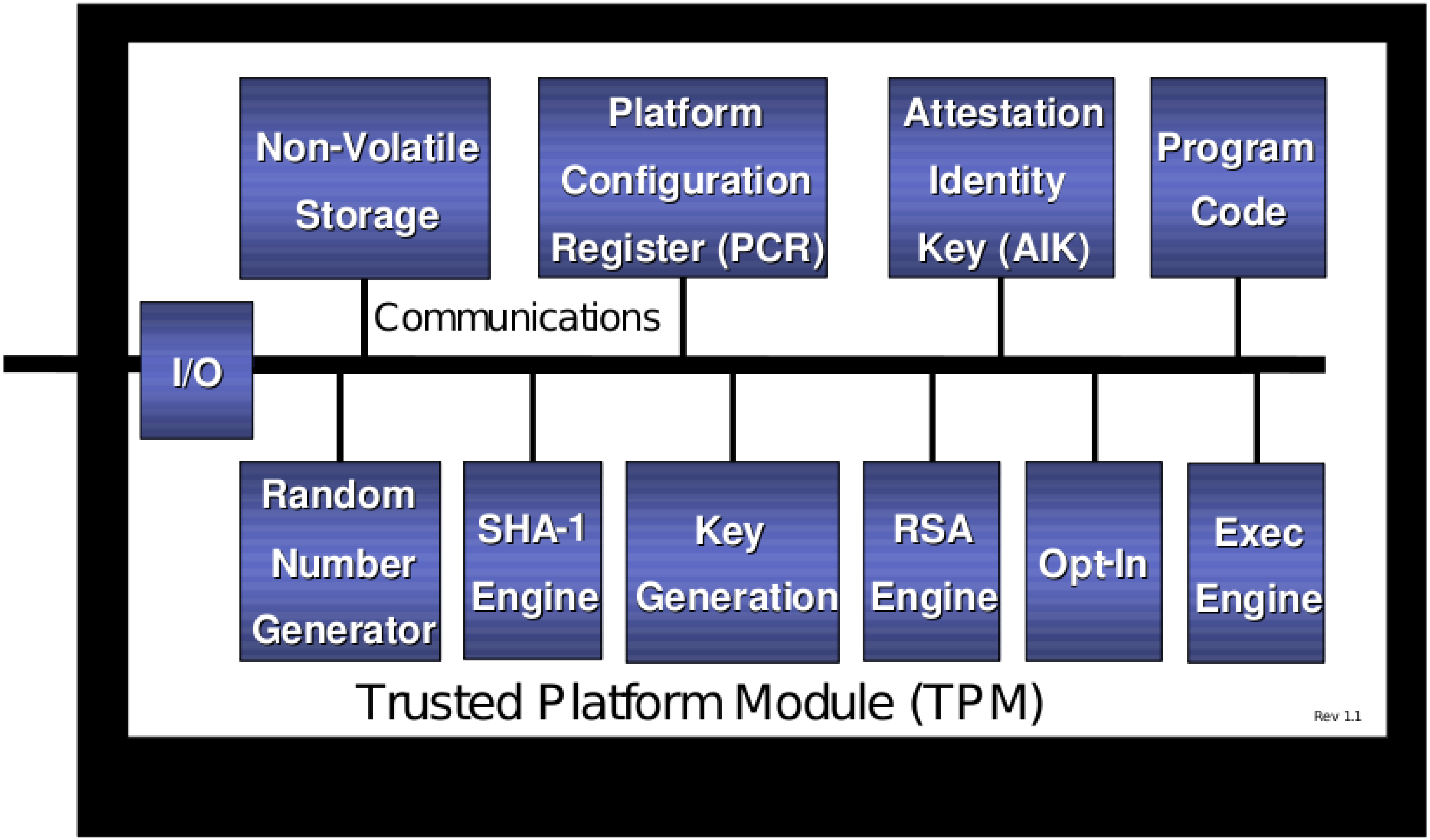
- Trusted Platform Module
- from the Trusted Computing Group (TCG)
  - http://www.trustedcomputinggroup.com/
  - « ... open, vendor neutral, industry standards for hardware-enabled trusted computing and security... »
  - Promoters (2008)
    - AMD, Fujitsu, HP, IBM, Infineon, Intel, Lenovo, Microsoft, Seagate, Sun, Wave
  - Contributors, Adopters... (140 members)
  - successor of TCPA (and competing Palladium?)
  - established in 2003

TCG Architecture



Very generic reference architecture

A TPM with RTR+RTS



Fundamental Trusted Platform Features

- Protected capabilities
  - shielded locations (register, memory, etc.)
  - and: key management, RNG, sealing, etc.
- Attestation
  - by the TPM, to the platform, of the platform, authentication of the platform
- Integrity Measurement, Logging and Reporting
  - metrics of integrity and digests (PCR)
  - recommended logging (optional)
  - attesting measurements
  - → independent process to evaluate integrity (platform cannot lie)

Use on Linux

http://www.grounation.org/index.php?post/2008/07/04/8-how-to-use-a-tpm-with-linux

- Enable TPM in BIOS / Load drivers
- Install tpm-tools and TrouSers
- Take Ownership (once and for all)
- (Compile) Install and setup TrustedGRUB
  - Restart successfully
  - Contemplate PCRs
    - PCR 0 to 3 for the BIOS, ROMS...
    - PCR 4 contains MBR information and stage1
    - PCR 8,9 contains bootloader information stage2 part1,2
    - PCR 12 contains all commandline arguments from menu.lst and those entered in the shell
    - PCR 13 contains all files checked via the checkfile-routine
    - PCR 14 contains all files which are actually loaded (e.g., Linux kernel, initrd, modules...)
    - PCR 15 to 23 are not used

Use on Linux

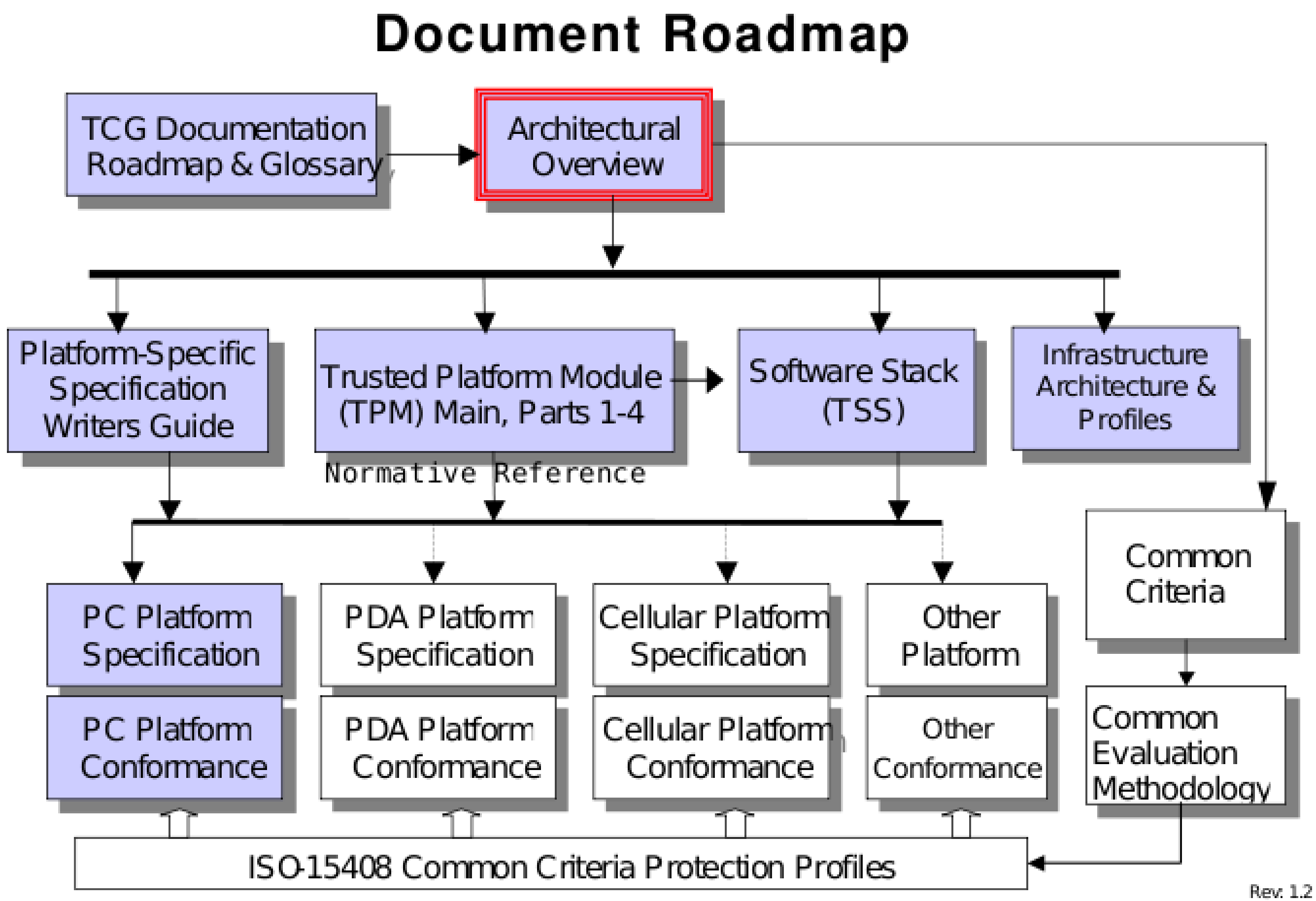
http://www.grounation.org/index.php?post/2008/07/04/8-how-to-use-a-tpm-with-linux

- Use some TPM features
  - Add some « checkfile » or « pcr_verify » to grub.lst

```
/somehwere/check.file
 fedb1cff009e115f7f5f7b4533667a787798832d (hd0,1)/test1.file
 485214eab2de87284de9d4e323e428bf60e0aa77 (hd0,1)/grub-0.92.tar.bz2
 a6e171e989849dd44735a513c4270a0837c09174 (hd0,1)/test2.file
```

  - Restart successfully
- NB : Do ***not*** forget the
  - Owner password
  - Storage Root Key (SRK) password
  - or stick to the precise software installed at setup time
    - with security verifications still enforced
    - and if you disabled boot on CD/DVD/USB of course...
- Extend to :
  - TPM KeyRing
  - Ecryptfs PKI...

Trusted Computing Group (TCG) and Trusted Platform Module (TPM)



http://www.trustedcomputinggroup.com/

Other issues with TPM

- « (...) *The TPM has the EK generated before the end customer receives the platform.* (...)
  1. The EK MUST be a 2048-bit RSA key (...)
  c. The PRIVKEY SHALL exist only in a TPM-shielded location (...) »
  - *TPM Main Part 1 Design Principles*, *Specification*, Version 1.2, Level 2 Revision 103, 9 July 2007.
    Section 5 (lines 1004-1040).
- « ... *If it's good enough for the NSA, it should be good enough for you*. »
  - Roger L. Kay, *Trusted Computing is Real and it's Here*, 2007.
- Trusted Computing or « *Treacherous Computing* » ?
  - (several) *anonymous*

Contrast with UEFI

- Microsoft Secure boot
- The initial master key is controlled by Seattle
- And it delegates...

- Side note
  - Fortunately, there is JTAG...

Overall presentation (1/2)

- Fast paced computer security walkthrough
  - Security properties
  - Attacks categories
  - Elements of cryptography
  - Introduction to mandatory security policies
- Embedded systems and security
  - Specificities
  - Physical attacks (SPA, DPA)
  - TPM
- **Software development and security**
  - **Security requirements and process**
  - Static verification and software development tools
  - Common criteria / ISO 15408

Introductory programmer comment

World-writable memory on Samsung Android phones

Posted Dec 17, 2012 20:13 UTC (Mon) by **mikov** (subscriber, #33179) [Link]

My experience from most places: nobody cares, nobody reviews. If a problem is discovered later, we will fix it later - why worry now and delay the release? What "/dev/mem"?? Enough with this mumbo-jumbo we have a release to make and management bonuses to earn.

In fact people who do care and worry about esoteric things like "security", or "good design" or "code quality" are universally viewed as trouble-makers or ivory tower idiots both by management and most of the engineers. It is an uphill battle even to do what used to be the baseline 10-15 years ago.

Commercial software engineering now is no different from accounting. The glory days are gone. It is all downhill from now on.

http://lwn.net/Articles/529496/

BTW, Cyanogen fix: http://review.cyanogenmod.org/#/c/28568/

Problem to address (with respect to security requirements definition)

- Best ROI when done at application design phase
- When considered at all, they tend to be
  - general lists of security features
    - password, firewalls, antivirus, etc.
  - implementation mechanisms ≠ security requirements
  - intented to satisfy *unstated* requirements
    - authenticated access, etc.
- Exist in a section by themselves (copied from a generic set)
  - no elicitation or analysis process, no adaptation to the target
- Significant attention is given to what the system should do
  - little is given to what it should not do *(in req. eng.)*
- Priority is not given to security (wrt ease of use for example)

Note on security updates

- How can we manage software vulnerabilities?
  - Wait until they are exploited by an attacker
  - Quickly provide a patch that should correct the problem (without introducing another one)
  - Whine because system administrators do not install patches fast enough

- Astonishingly it is very popular
  - All serious editors do that
  - Users feel more secure (still?)

Improving security Using Extensible Lightweight Static Analysis, David Evans and David Larochelle, *IEEE Software*, January/February 2002.

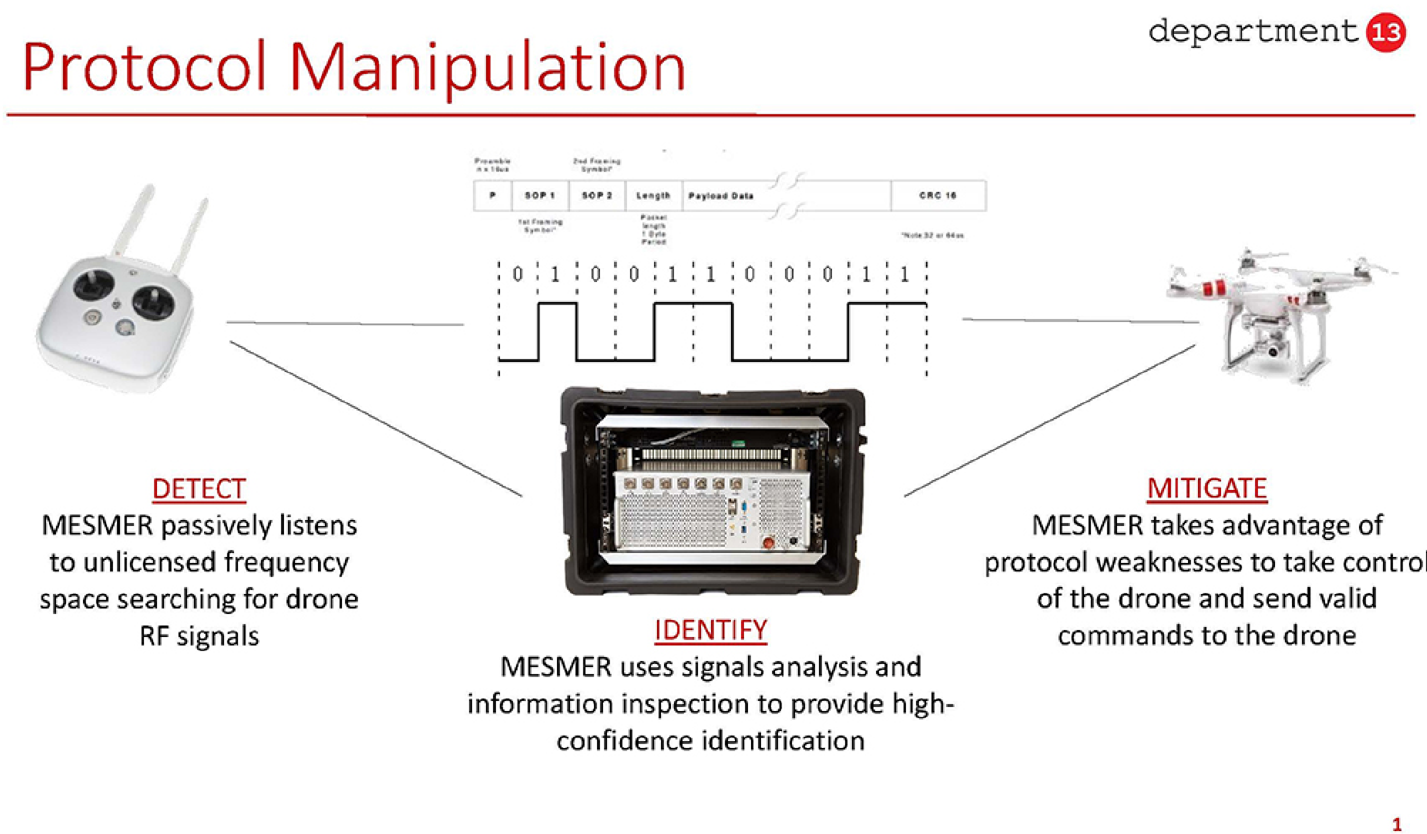
Drones firmware security update

- DJI firmware update
  - february 2015
  - Phantom 2
  - Phantom 2 Vision (+)
- integrates
  - a no-fly zone
  - 15.5 miles radius
  - around the...
    - White House
- guess why ?

- et l'Elysée au fait ?

Speaking of point of view...

“Countering the Threat of Unauthorized Drones with ...”



In other words

- It is not enough to apply patches to secure a system
- Also, you cannot rely only on firewalls or antivirus (or IT security tools)
- Security objectives of a piece of software should be identified
- Security implies a change in point of view
  - e.g.: it must *not* work
  - unavailable is better than destroyed
  - which (computer) is saved first ?

- i.e. : What do you *really* want *exactly* ?

Another view on project lifecycle

- Detailed needs ?
- Specs ?
- Contracts
- Development
- Integration
- Validation
- Exploitation
- Maintenance
- Disposal ?

Security policy consideration

Security specification

Security validation/configuration

Monitoring / Management

Quid ?

Risk analysis

1. Identify assets and their value ($$)
2. Define assets priority
3. Identify vulnerabilities, threats and potential damages
4. Define threats priority
5. Optimize counter-measures selection

- Inherently qualitative (human/expert opinion)
- Applicable to organization, system, project
- Several methods available
  - MARION, MEHARI, EBIOS, etc.
  - HAZOP, FMEA, ISO31000, etc.

Pros (my view)

- *Identification* of assets and their relative values
- Assets value offers an opportunity to budget realistically (for protection)
- Is understandable by end users
  - Quite easier than assembly language exploits or cryptographic hash functions
- Risk management alternatives
  - Transfer (insurance, state, etc.)
  - Acceptance (life is deadly after all)
  - Reduction (work, work, work, work, ...)
  - Avoidance (just do it the other way)
- Management could express clear priorities

Cons (my view)

- Threat determination is an oracle problem
- May be used to demonstrate that (any) risk is (already) managed
  - Some forgotten successes of risk management
    - Lehman-Brothers financial risk exposure
    - Greek debt control
  - Qualitative also means manipulable
- Relies a lot on best practices or risks lists
  - Fuels paranoia and ready-made useless tools
  - Does not help target real assets
- Management rarely wants to decide
- Sometimes does not end well morally speaking
  - For example : product lifetime optimization
    (NB : Inherently viewpoint-based)

Threats and use-case examples

- Trusted Computing Group
  - Mobile phone TPM use-case scenarios
  - *(Name,) Goal*
    - *Threats*

- Platform integrity
  - Ensure that device possess and run only authorized operating system(s) and hardware
    - Logic of device firmware modified
    - Device hardware modified
    - Device functions in a manner other than intended by the manufacturer
    - Device modified to broadcast false identification (IMEI)

Threats and goals examples

OLD
AND THEN?

- Device authentication
  - Assist user authentication
  - Prove identity of device itself
    - Identity spoofing to get unauthorized access to services
    - Identity no longer bound to the device
    - Theft of device
    - Device tracking
- Robust DRM implementation
  - Service and content providers need assurance that the device DRM is robust
- SIMLock / Device personalisation
  - Ensure that a mobile device remains locked on a particular network

Last use-case examples (for info.)

OLD
AND THEN?

- Secure software download
- Secure channel between device and UICC (UMTS Integrated Circuit Card)
- Mobile Ticketing
- Mobile Payment
- Software use
  - User-available predefined software use policies
- Proving platform and/or application integrity to end user
- User data protection and privacy

References

- DHS « Build Security In »
  - https://buildsecurityin.us-cert.gov/
- The Addison-Wesley Software Security Series
  - http://www.softwaresecurityengineering.com/series/
- CERT/CC
  - http://www.cert.org/
- « *Smashing the Stack for Fun and Profit.* »
  - Aleph One, Phrack Magazine 7, 49 (1996) File 14 of 16.
- OpenBSD
  - http://www.openbsd.org/papers/

Some real programming

- Presentation based on work from real programmers in the neighbourhood
- First, sources :
  - Matthieu Herrb & lots of OpenBSD « good programming » examples
  - Vincent Nicomette and Eric Alata for some « details »

Now real programming (*prereq*.)

```
#include <stdio.h>
void copie(char * s) {
  char ch[8] = "BBBBBBBB" ;
  strcpy(ch,s) ;
}
int main(int argc, char * argv[]) {
  copie(argv[1]) ;
  return(0);
}
```

AAAAAAAAAAAA[system_adr][exit_adr][shlibc_adr]

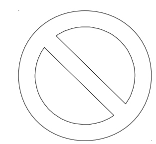
Bash$./a.out 'perl -e 'print "A"x12 . 0xb7ee1990 . 0xb7ed72e0 . 0xb7fcc0af' '

sh-3.1$

Now real programming

- Number One : buffer overflow with string functions

```
strcpy(path, getenv("$HOME"));
strcat(path, "/");
strcat(path, ".foorc");
len = strlen(path);
```



- strcat(), strcpy()
  - no verification on buffer size, dangerous : do not use
- strncat(), strncpy()
  - leave strings non terminated, very difficult to use correctly
- strlcat(), strlcpy()
  - May truncate strings, but probably easier to use

http://homepages.laas.fr/matthieu/cours/mh-prog-defensive.pdf

str{,n,l}{cpy,cat} practical usage

```
STRCAT(3)                  Linux Programmer's Manual                 STRCAT(3)

NAME
       strcat, strncat - concatenate two strings

SYNOPSIS
       #include <string.h>

       char *strcat(char *dest, const char *src);

       char *strncat(char *dest, const char *src, size_t n);
```

No strlcat() on Linux ; so, from the BSDs (more precisely OpenBSD) :

```
size_t strlcpy(char *dst, const char *src, size_t dstsize);
size_t strlcat(char *dst, const char *src, size_t dstsize);
```

No strlcat on Linux...

strncat() is difficult to use

```
strncpy(path, homedir, sizeof(path) – 1) ;
path[sizeof(path) – 1] = '\0' ;
strncat(path, "/", sizeof(path) – strlen(path) – 1) ;
strncat(path, ".foorc", sizeof(path) – strlen(path)
    – 1) ;
len = strlen(path) ;
```

Note (on Linux) : g_strlcpy() and g_strlcat() exist in glib-2.0
Note (on BSD) : see next slide (*Yeah !!!)*
Additional note: C11 has removed gets() (was deprecated in C99) replaced by ***gets_s()***

strl*() look better

```
strlcpy(path, homedir, sizeof(path)) ;
strlcat(path, "/", sizeof(path)) ;
strlcat(path, ".foorc", sizeof(path)) ;
len = strlen(path) ;
```

- May truncate, but no overflow

- Add checks for non testing code :

```
strlcpy(path, homedir, sizeof(path)) ;
if (len >= sizeof(path)) return (ENAMETOOLONG) ;
strlcat(path, "/", sizeof(path)) ;
if (len >= sizeof(path)) return (ENAMETOOLONG) ;
strlcat(path, ".foorc", sizeof(path)) ;
if (len >= sizeof(path)) return (ENAMETOOLONG) ;
len = strlen(path) ;
```

C11 Annex K (ISO/IEC 9899:2011)

- C11 Ann.K « Bounds-checking interfaces » defines alternative versions of standard string-handling functions (from Microsoft)
- strcpy_s(), strcat_s(), strncpy_s() and strncat_s()
- *ie* :

```
errno_t strcpy_s(
char * restrict s1,
rsize_t s1max,
const char * restrict s2
);
```

- See also : ISO/IEC TR24731-1:1999 and ISO/IEC:TR24731-2:2010 …
- Note : wchar_t

STR07-C. Use the bounds-checking interfaces for remediation of existing string manipulation cod - Window...

Compliant Solution (Runtime)

The following compliant solution will not overflow its buffer.

```
void complain(const char *msg) {
  errno_t err;
  static const char prefix[] = "Error: ";
  static const char suffix[] = "\n";
  char buf[BUFSIZ];

  err = strcpy_s(buf, sizeof(buf), prefix);
  if (err != 0) {
    /* handle error */
  }

  err = strcat_s(buf, sizeof(buf), msg);
  if (err != 0) {
    /* handle error */
  }

  err = strcat_s(buf, sizeof(buf), suffix);
  if (err != 0) {
    /* handle error */
  }

  fputs(buf, stderr);
}
```

Compliant Solution (Partial Compile Time)

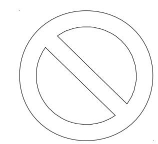
The following compliant solution performs some of the checking at compile time using a static assertion. (See DCL03-C. Use a static assertion to test the value of a constant expression.)

Raw C11 example
from https://www.securecoding.cert.org/

Time of check, time of use

- How to create a temp. file in /tmp without overwriting an existing file ?

```
/* Generate random file name */
name = mktemp("/tmp/tmp.XXXXXXXXXX");
/* verify file does not exist */
if (stat(name,&statbuf) == 0) {
    return EEXISTS;
}
/* ok, open it */
fd = open(name, O_RDWR);
```



- Opens a possible race condition with a concurrent process
- mktemp() deprecated in POSIX.1 (2011)

Options

- Use mkstemp() to replace both system calls
```
fd = mkstemp("/tmp/tmp.XXXXXXXXXX") ;
```
- Use O_CREAT | O_EXCL, open() flags that trigger an error if the file already exists
```
fd = open(name, O_CREAT | O_EXCL);
```

- Note the difference between fopen() and open() return types (FILE* vs. int or streams vs. file descriptors)

Arithmetic overflows

```
n = getIntFromUser();
if (n<=0 || n*sizeof(struct item) > BUFMAX){
    return EINVAL;
}
```

- If *n* is big enough, the condition will not be true
- Use :

```
n = getIntFromUser();
if (n<=0 || n > BUFMAX/sizeof(struct item)){
    return EINVAL;
}
```

Arithmetic overflows

```
n = getIntFromUser();
if (n<=0){
    return EINVAL;
}
data = (struct item *)
    malloc(n * sizeof(struct item));
if (data == NULL) {
    return ENOMEM;
}
```

- If *n* is big enough, overflow occurs and a small memory allocation is done
  - opening the path to a memory overflow
- Use calloc() !

```
data = (struct item *)
    calloc(n, sizeof(struct item));
```

Format strings issues

- Many standard display functions use a format for printing : printf(), sprintf(), fprintf(), …
- Two variants exist, with and without format strings : printf("%s", ch) or printf(ch)
- What happens when you give « %x » to printf ?
  - printf() gets its next argument from the stack
- When user input is passed to such functions, it can generate this kind of situations
- This kind of situation may allow to access areas of memory for reading (sometimes for writing)

Example

```
#include <stdio.h>
int main()
{
    char * secret = "polichinelle";
    static char input[100] = {0};
    Printf("Enter your name: ");
    scanf("%s", input);
    printf("Hello ");printf(input);printf("\n");
    printf("Enter your password: ");
    scanf("%s",input);
    if (strcmp(entree,secret)==0) {
        printf("OK\n");
    } else {
        printf("Error\n");
    }
    return 0;
}
```

Example

- Normal use of the program

```
bash$ ./a.out
Enter your name: Jack
Hello Jack
Enter your password: ripper
Error
```

- « Abuse » of the program

```
bash$ ./a.out
Enter your name: %p%s
Hello 0x08049760polichinelle
```

- Allows to walk the stack and access internal program data

Practical recommendations

- Design first
  - Often broken and insecure by design
- Obscurity does not help
  - Exploits against closed source may be just as easy as against open source
  - Obfuscation primarily works for people writing code, not crackers
- Quality is security
  - Most security problems are simple bugs
  - There is no security plugin
  - No ROI for security
    - But shorter test cycles
    - Less bugs, so less time spent fixing them
    - And usually better efficiency

Practical recommendations

- Most code should be simple and boring
  - Easier to audit
  - Already formatted
  - Clever code is almost always wrong
- Fix a bug everywhere
  - Even automate for checking it
- Check return codes
- Design your APIs right...
- Understand semantics
  - File descriptors
    - Inheritance over fork
    - Access rights only checked on open()
  - Signal handlers *are* complex
    - Simple rule : only set volatile atomic flags in them

Practical recommendations

- Most security issues come from abstraction layers violation (audit these cases)
  - Hidden variables
  - Concurrency
  - Overflows
  - Flow control on error
- All user input must be checked
  - Positive checks
  - Everything not static is like user input
- Be careful with optimizations
- There is no secure language or environment
  - Java does not suffer from simple buffer overflows but has integer overflows, logic errors, etc.

Overall presentation (1/2)

- Fast paced computer security walkthrough
  - Security properties
  - Attacks categories
  - Elements of cryptography
  - Introduction to mandatory security policies
- Embedded systems and security
  - Specificities
  - Physical attacks (SPA, DPA)
  - TPM
- Software development and security
  - Security requirements and process
  - **Static verification and software development tools**
  - Common criteria / ISO 15408

Capabilities of Security Analyzers

- Examining Calls to Potentially Insecure Library Functions
- Detecting Bounds-Checking Errors and Scalar Type Confusion
- Detecting Type Confusion Among References or Pointers
- Detecting Memory Allocation Errors
- Detecting Vulnerabilities that Involve Sequences of Operations (Control-Flow Analysis)
- Data-Flow Analysis (reducing false alarms)
- Pointer-Aliasing Analysis (primarily useful for the former)
- Customizable Detection Capabilities

Classes of Tools

- Source code analysis tools
  - see below
- Penetration testing tools
  - Ports scanners
    - e.g. nmap
  - Vulnerability scanners
    - e.g. Nessus, ISS's Internet Scanner
  - Application scanners
  - Web application assessment proxy

Analyzer mechanics

- « simple » searching (grep-like)
- lexical analysis
- abstract syntax tree (AST) construction (parsing)
- advanced work (may) start here
  - global / local analysis
  - type calculus, logical reasoning, range calculus
  - false alarms reduction techniques
  - IDE integration, specification-based verification
  - etc.

Some surveys

- OWASP
  - https://www.owasp.org/index.php/Source_Code_Analysis_Tools
- NIST
  - https://samate.nist.gov/index.php/Source_Code_Security_Analyzers.html
  - https://samate.nist.gov/

Examples *(somehow outdated)*

- Splint - http://www.splint.org/
  - evolution of good-old lint
  - lightweight static analysis
- smatch - http://smatch.sourceforge.net/
  - source checker focused on linux kernel code
  - links with sparse
  - Died, and resurrected : *TBD* again
- ASTREE - http://www.astree.ens.fr/
  - LIENS, started Nov. 2001
  - C programs
  - real-time embedded software static analyzer
  - based on abstract interpretation

Splint – Quotes from the authors

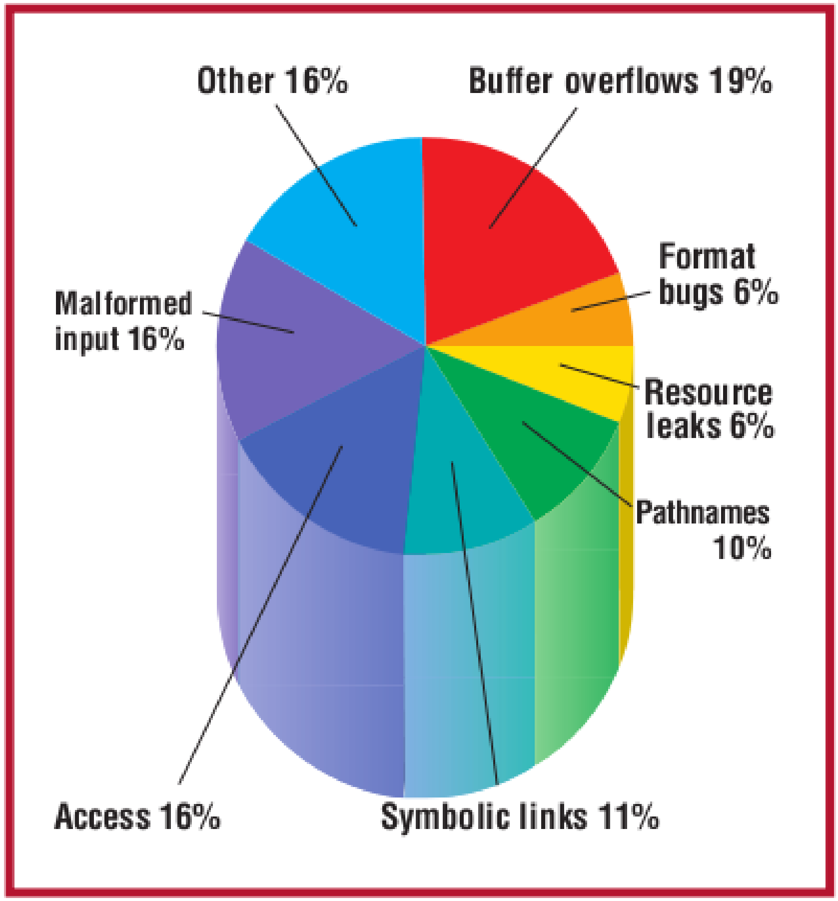


Figure 1. Common Vulnerabilities and Exposures list for the first nine months of 2001. Most of the entries are common flaws detectable by static analysis, including 37 buffer overflow vulnerabilities.

- A tool knowing common vulnerabilities
- Exploiting annotations in programs
- Automated checking

Improving security Using Extensible Lightweight Static Analysis, David Evans and David Larochelle, *IEEE Software*, January/February 2002.

Annotation examples

Library functions :

```
char *strcat (/*@returned@*/ char *s1, char *s2)
 /*@ensures s1:taintedness =
       s1:taintedness | s2:taintedness@*/;

char *strcpy (char *s1, const char *s2)
 /*@requires maxSet(s1) >= maxRead(s2)@*/
 /*@ensures maxRead(s1) == maxRead(s2)
      /\ result == s1@*/;
```

False alarms

Table 1

False warnings checking wu-ftpd

Cause	Number	Percent
External assumptions	6	7.9
Arithmetic limitations	13	17.1
Alias analysis	3	3.9
Flow control	20	26.3
Loop heuristics	10	13.2
Other	24	31.6

Smatch

- http://repo.or.cz/w/smatch.git
- Smatch uses Sparse as a C parser
- validation/validation_sm_buf_size6.c

Source C test fragment

```
#include "check_debug.h"

void *malloc(int size);

int function(void)
{
        int *p;
        int array[1000];

        p = malloc(4000);

        __smatch_buf_size(p);
        __smatch_buf_size(&p[0]);
        __smatch_buf_size(array);
        __smatch_buf_size(&array);
        __smatch_buf_size(&array[0]);

        return 0;
}
```

Used to test the analyzer itself

Test fragment output

```
/*
 * check-name: smatch buf size #6
 * check-command: smatch --spammy -I.. sm_buf_size6.c
 *
 * check-output-start
sm_buf_size6.c:12 function() buf size: 'p' 1000 elements, 4000 bytes
sm_buf_size6.c:13 function() buf size: '&p[0]' 1000 elements, 4000 bytes
sm_buf_size6.c:14 function() buf size: 'array' 1000 elements, 4000 bytes
sm_buf_size6.c:15 function() buf size: '&array' 1000 elements, 4000 bytes
sm_buf_size6.c:16 function() buf size: '&array[0]' 1000 elements, 4000 bytes
 * check-output-end
 */
```

ASTREE

- Example of abstract interpretation application to software analysis

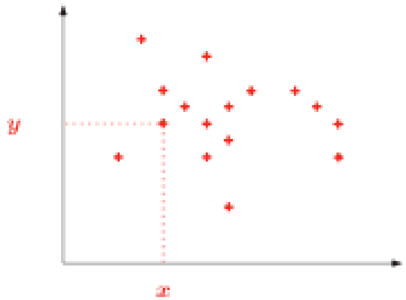
- Properties / objectives
  - sound (all possible errors)
  - automatic (no invariants required)
  - efficient
  - domain-aware, parametric, modular, extensible
  - hence, very precise
- Application / achievements
  - A340 fly-by-wire control software (C, 132kloc, 2003)
  - A380 electric flight control codes (2004)
  - C version of ATV automatic docking software (2008)

Abstract interpretation

- Formalize the idea of approximation
  - to bring the correctness problem at range
- Application of abstraction to
  - the semantics of programming languages
  - static program analysis
- competes with
  - deductive methods
  - model-checking
  - type inference

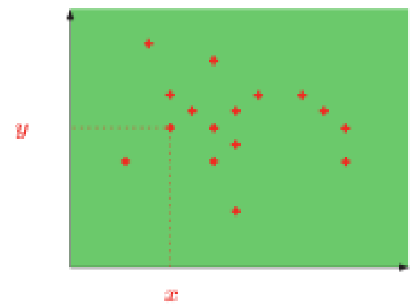
A glance at the theory (1/3)

Simple abstraction



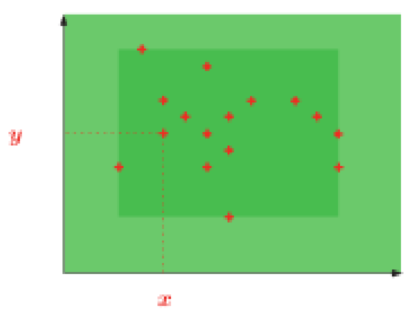
$\{\ldots, \langle 5, 7\rangle, \ldots, \langle 13, 21\rangle, \ldots\}$

(a) [In]finite Set of Points



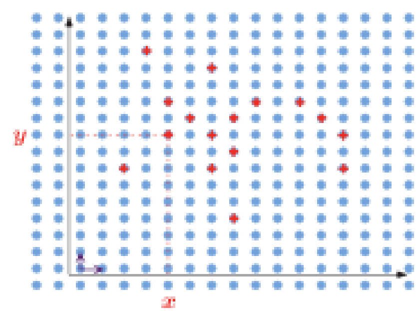
$\begin{cases} x \geq 0 \\ y \geq 0 \end{cases}$

(b) Sign Abstraction



$\begin{cases} x \in [3,\ 27] \\ y \in [4,\ 32] \end{cases}$

(c) Interval Abstraction



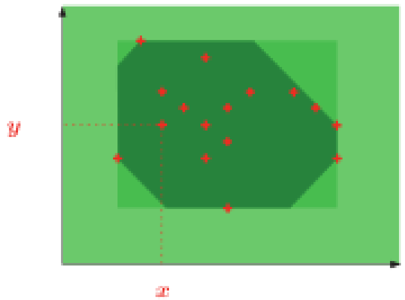
$\begin{cases} x = 5 \bmod 8 \\ y = 7 \bmod 9 \end{cases}$

(d) Simple Congruence Abstraction

Abstract Interpretation Based Formal Methods and Future Challenges, Patrick Couzot, in *Informatics, 10 Years Back - 10 Years Ahead*, R. Wilhelm (Ed.), LNCS 2000, 2001.

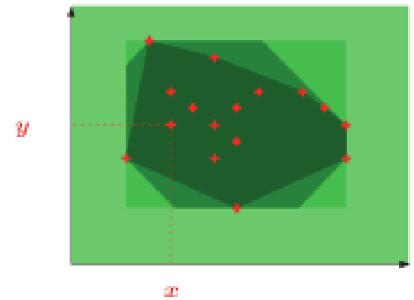
A glance at the theory (2/3)

Effective abstraction



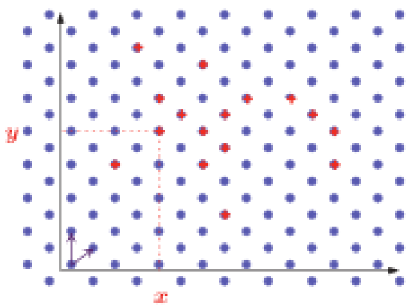
$$\begin{cases} 3 \leq x \leq 7 \\ x + y \leq 8 \\ 4 \leq y \leq 5 \\ x - y \leq 9 \end{cases}$$

(a) Octagonal Abstraction



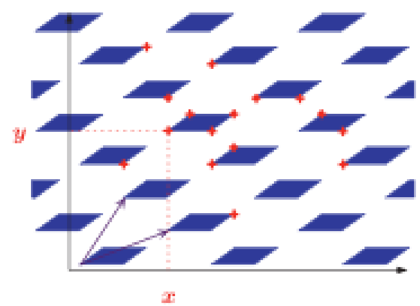
$$\begin{cases} 7x + 3y \leq 5 \\ 2x + 7y \geq 0 \end{cases}$$

(b) Polyhedral Abstraction



$$\begin{cases} 3x + 5y = 8 \bmod 7 \\ 2x - 9y = 3 \bmod 5 \end{cases}$$

(c) Relational Congruence Abstraction



$$\begin{cases} 3x + 7y \in [2, 7] \bmod 8 \\ 2x - 5y \in [0, 9] \bmod 4 \end{cases}$$

(d) Trapezoidal Congruence Abstraction

Abstract Interpretation Based Formal Methods and Future Challenges, Patrick Couzot, in *Informatics, 10 Years Back - 10 Years Ahead*, R. Wilhelm (Ed.), LNCS 2000, 2001.

A glance at the theory (3/3)

Information loss and checking

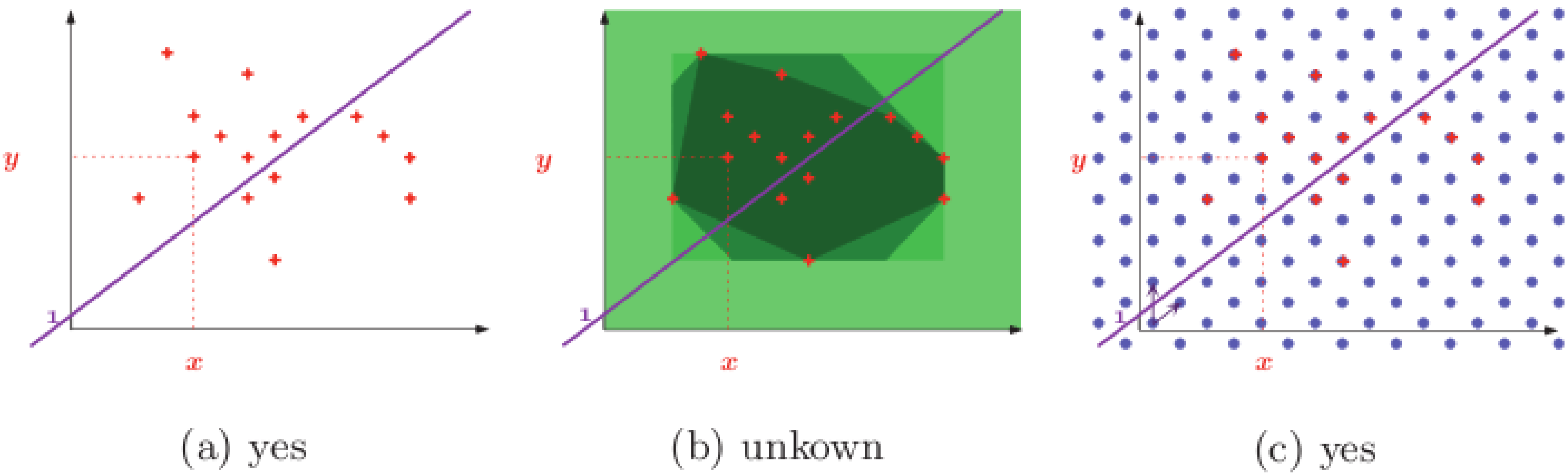


Fig. 10. Is 1/(X+1-Y) well-defined?

Abstract Interpretation Based Formal Methods and Future Challenges, Patrick Couzot, in *Informatics, 10 Years Back - 10 Years Ahead*, R. Wilhelm (Ed.), LNCS 2000, 2001.

Operation report

- Specialisation to synchronous avionics code
  - produced from SCADE, no scheduling
  - intensive use of booleans and floating points
  - existence of digital filters
- Full alarm investigation needed
- 200kloc (pre-processed) C, 10 000 globals, 6h
- 467 alarms, 327 after options
- « partitioning directive »: 11 alarms remaining
- « true alarm »
  - 0x80000000 defaults to unsigned int per ISO-C
  - write (-2147483647-1) **?**

Some concluding remarks

- Complete verification by formal methods
  - model checking / deductive methods
  - very costly in human ressources
  - not likely to scale up
- Partial verification by static analysis
  - cost effective
- Program debugging
  - remains the prominent industrial « verification » method
  - well know deficiencies: uncompleteness, cost

- NB: Fault removal, but also fault prevention, fault tolerance and fault forecasting

Overall presentation (1/2)

- Fast paced computer security walkthrough
  - Security properties
  - Attacks categories
  - Elements of cryptography
  - Introduction to mandatory security policies
- Embedded systems and security
  - Specificities
  - Physical attacks (SPA, DPA)
  - TPM
- Software development and security
  - Security requirements and process
  - Static verification and software development tools
  - **Common criteria / ISO 15408**

« Criteria »

- Genealogy
  - TCSEC – Trusted Computer System Evaluation Criteria – DoD 1985 (Orange book) and TNI – Trusted Network Interpretation of the TCSEC (Red book)
  - ITSEC – Information Technology Security Evaluation Criteria (EEC 1991)
  - JCSEC, CTCPEC, etc.
  - CC – Common Criteria also known as ISO15408 (ISO standard since ~2000)

Orange book : criteria (1/2)

- Security policy
  - discretionary access control
  - Object reuse control
  - Labels
  - Mandatory access control
- Imputability (?)
  - Identification and authentication
  - Trusted path
  - Audit
- Operational assurance
  - System architecture
  - System integrity
  - Covert channels analysis
  - Installation management
  - Secure recovery

Orange book : criteria (2/2)

- Life cycle assurance
  - Security tests
  - Specification and verification
  - Configuration management
  - Secure distribution
- Documentation
  - User guide
  - Secure installation manual
  - Tests documentation
  - Security management documentation

ITSEC - Criteria

- Functionality classes
- Assurance – Correctness : E1 to E6
- Assurance – Effectiveness
  - Construction
    - Suitability of functionality
    - Binding of functionality
    - Strength of mechanisms
    - Construction vulnerability assessment
  - Operation
    - Ease of use
    - Operational vulnerability assessment

Nice quote on criteria

- CC – ISO 15408
  - Common Criteria

« For the most part, the protection profiles define away nearly all of the interesting threats that most systems face today. » *in* Fedora and CAPP, lwn.net, 10 dec. 2008.

Not the end of story however (oldest standard).

Overall presentation (2/2)

- Case studies
  - Wireless networks
  - New generation avionics systems
  - Network appliances
  - Mobile telephony
  - Gaming devices
- Wrap-up (on-demand)
  - IDS
  - Firewalls
  - Tripwire
  - Metasploit
  - Anti-virus

Now

Photo: *resp.*

Still now

Automatic Taxi vs. Jeep Cherokee: 0wned!

Photo: Mark Harris

Photo: Zoox

Photo: Whitney Curtis for Wired

Photo: Andy Greenberg for Wired

Toaster hacking

Fridge

Une suggestion pour sauver
l'électroménager français :
la ***balance espion***

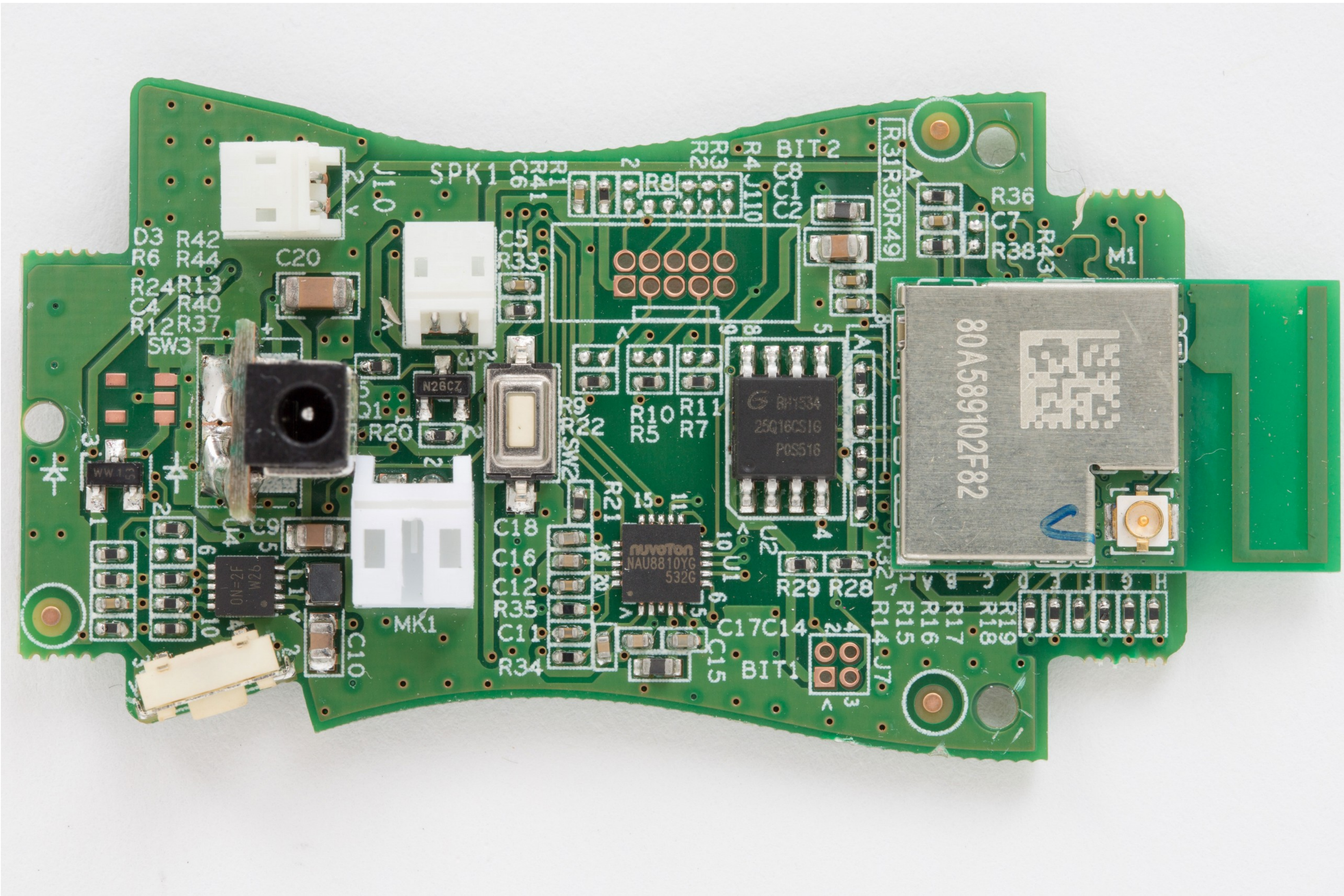
Already done!

Check too

- Abusive protection is the latest fashion...

Photo: Corbis

Nearly forgot to remember that

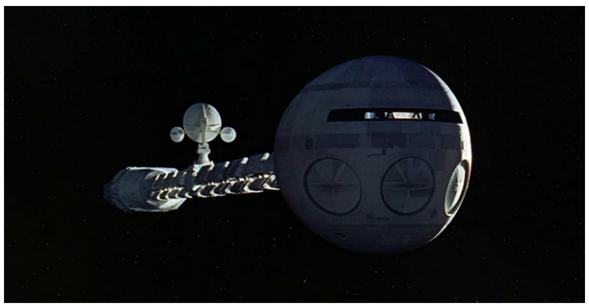


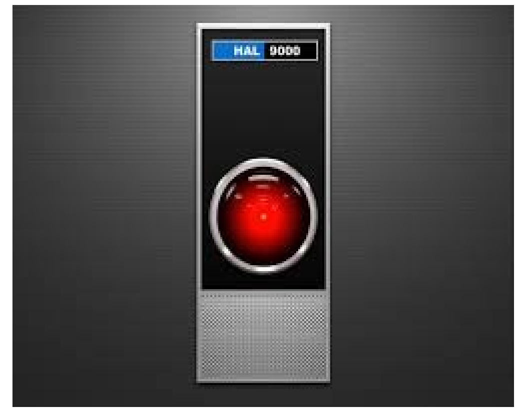
Next ?

vs.

The only sure thing is that it will be the user's fault.

NB : Past





HAL 9000

2001 Space odissey, Stanley Kubrick & Arthur Clarke, 1968.

Note (*2010 Odissey 2*): Contrary to duty imperative, R. Chisholm, 1963.

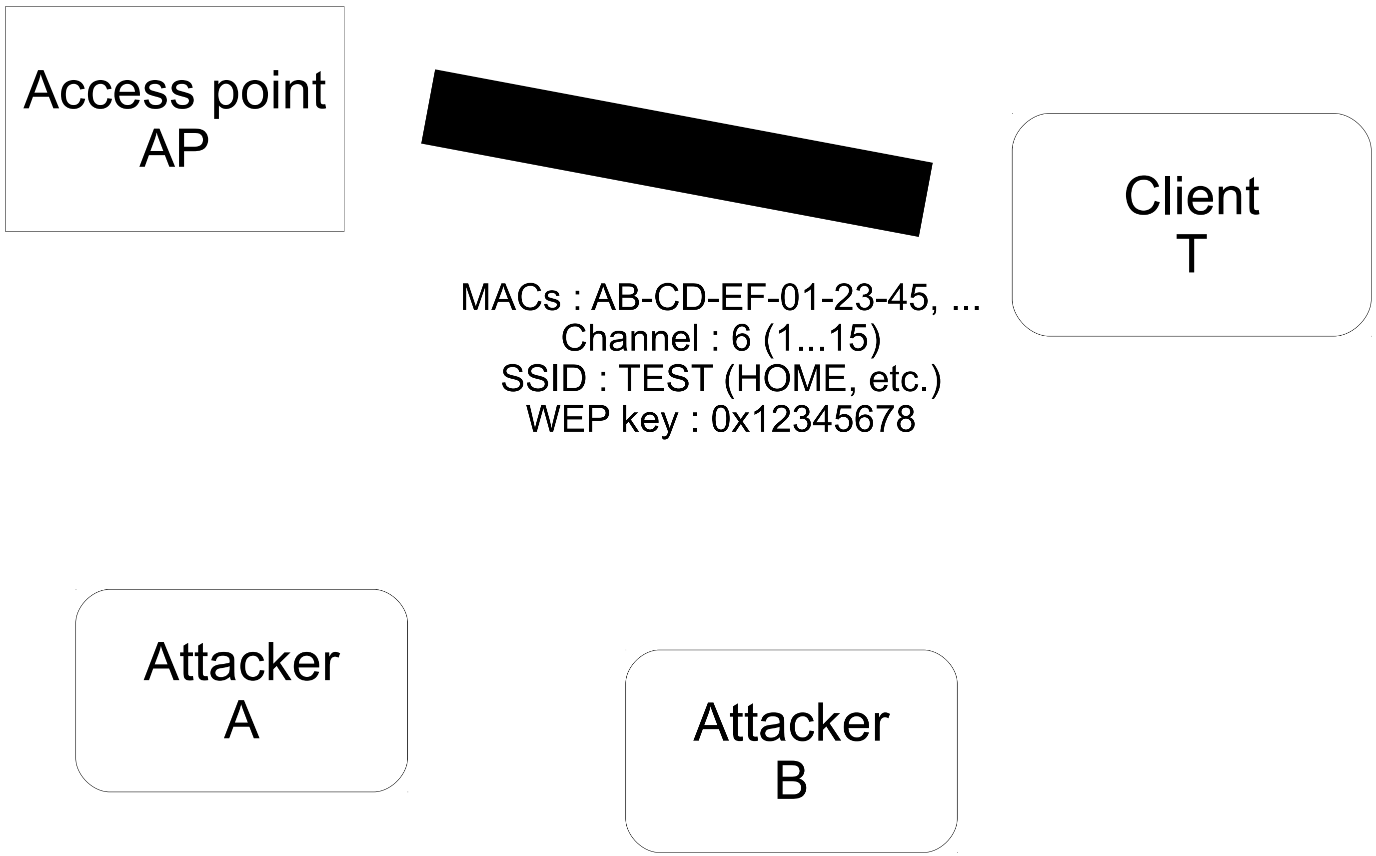
Overall presentation (2/2)

- Case studies
  - **Wireless networks**
  - New generation avionics systems
  - Network appliances
  - Mobile telephony
  - Gaming devices
- Wrap-up (on-demand)
  - IDS
  - Firewalls
  - Tripwire
  - Metasploit
  - Anti-virus

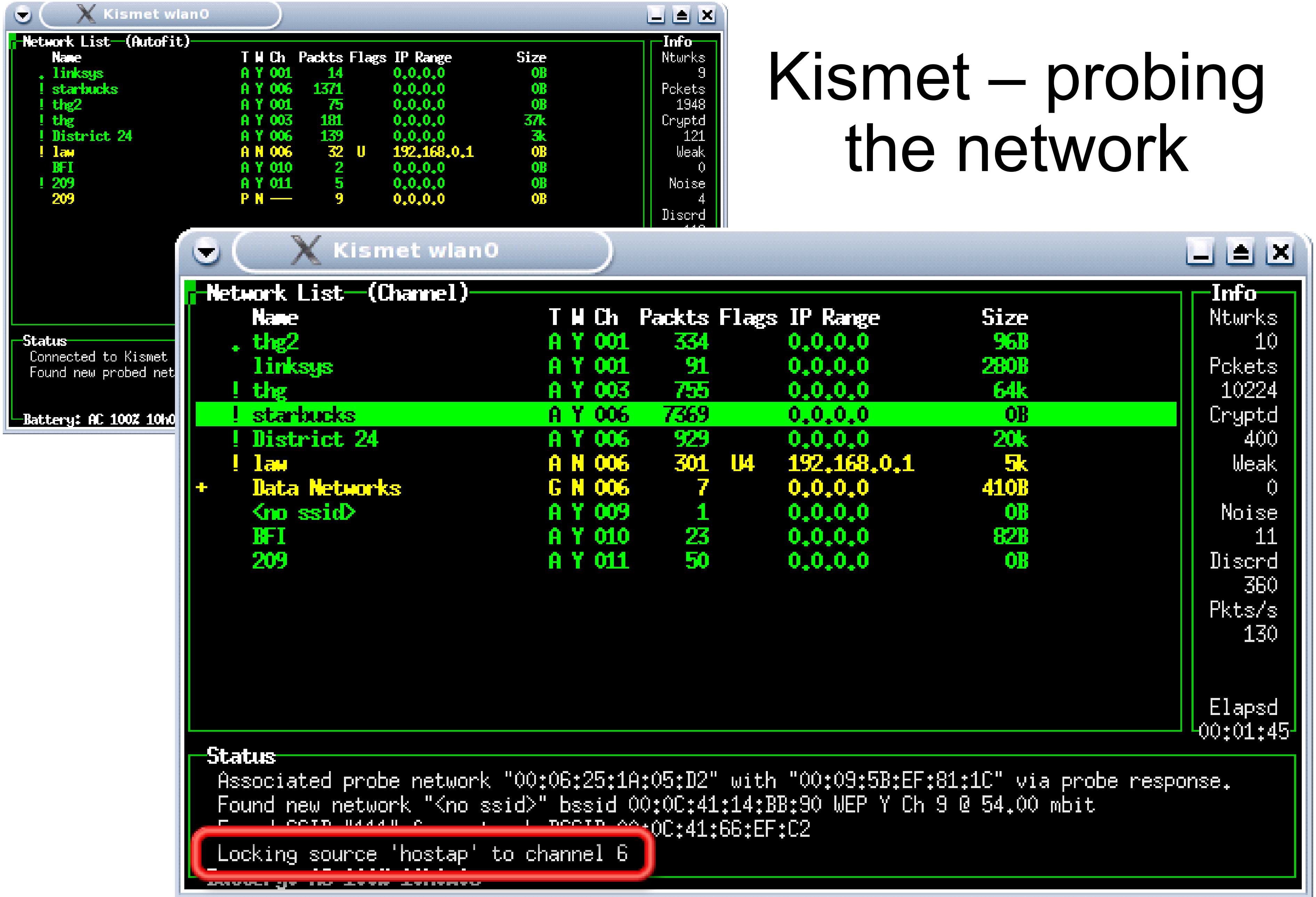
A wireless network

- WiFi
  - IEEE 802.11a/b/g
  - radio waves
- secured by WEP
  - design fault : uses RC4
  - deprecated : WPA(TKIP), WPA2(CCMP), EAP
- attack example
  - source: Tom's Hardware Guide, 10&18/05/2005
  - tools: kismet, airodump, void11, aireplay, aircrack

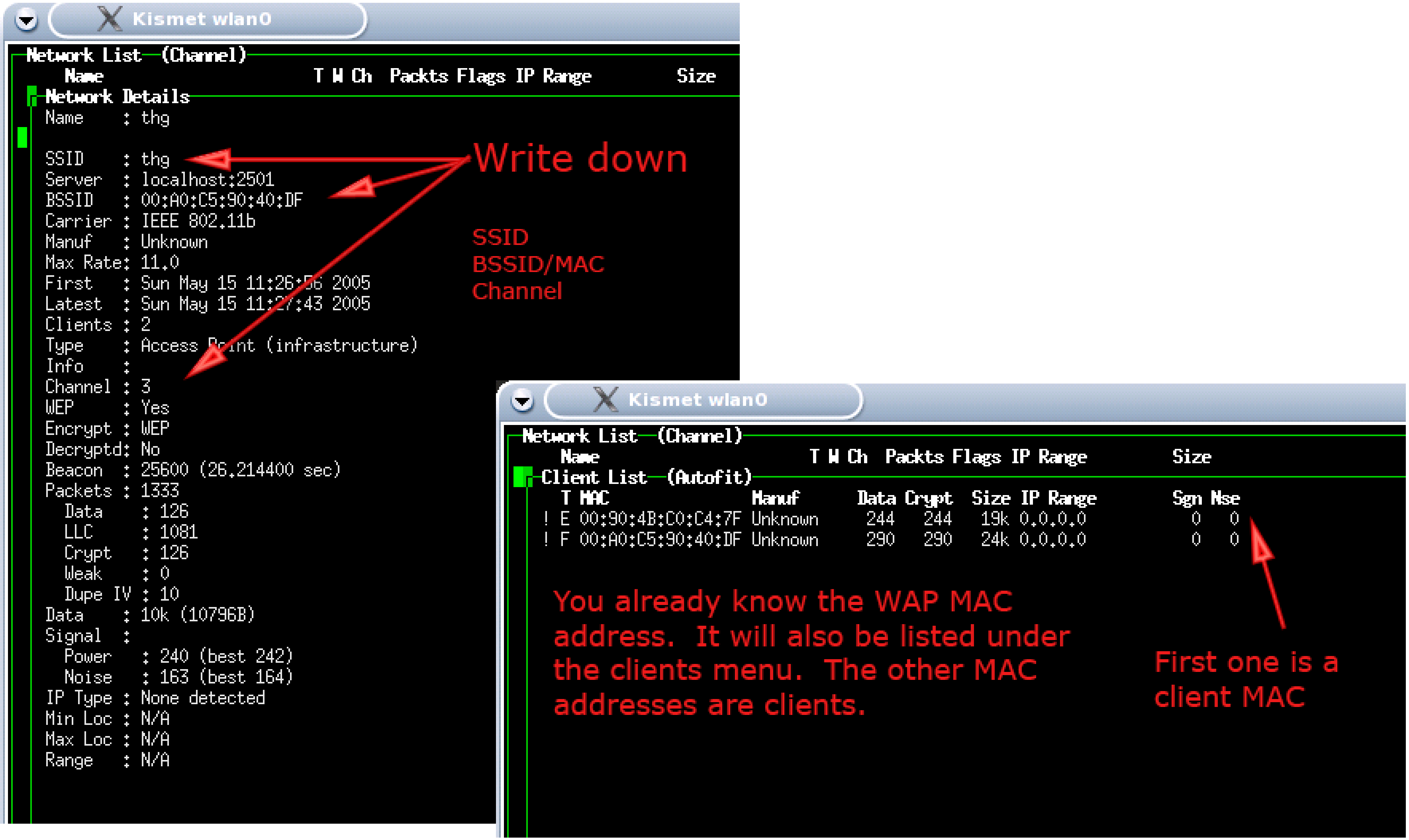
Test network



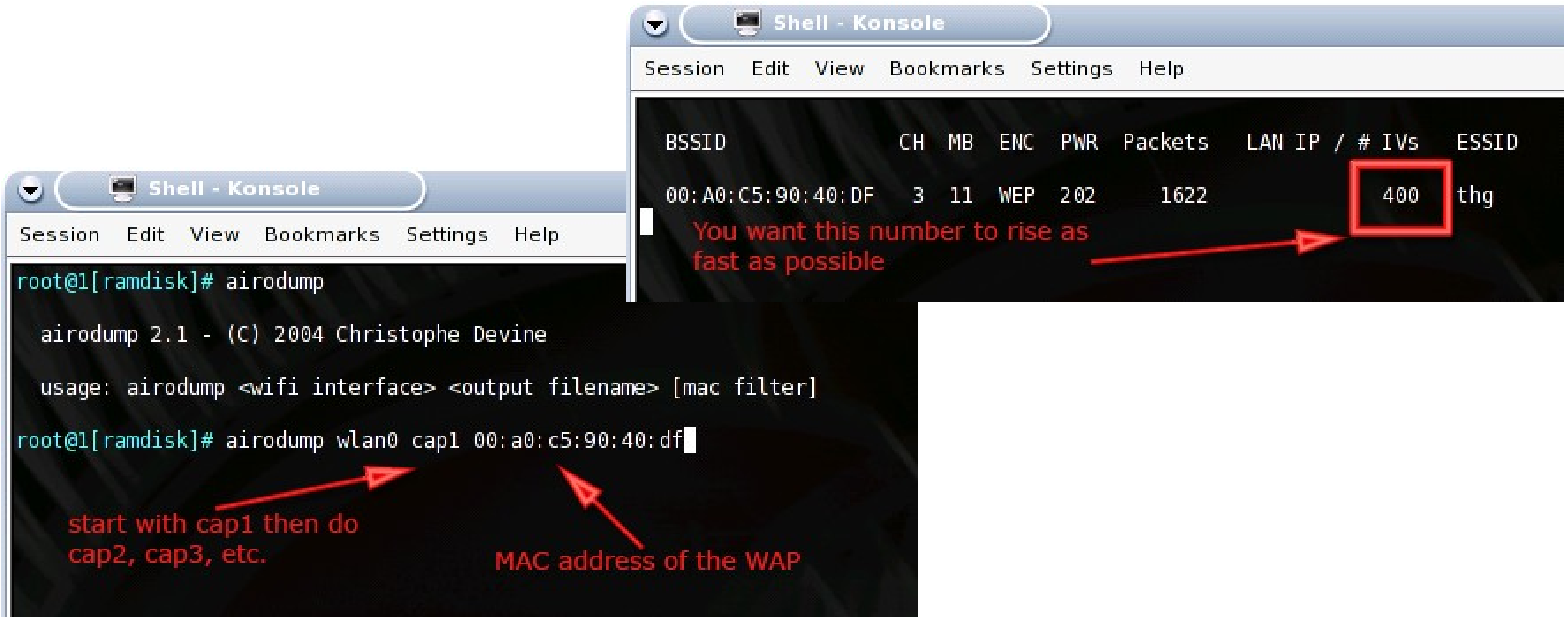
Kismet – probing the network



Kismet – targetting



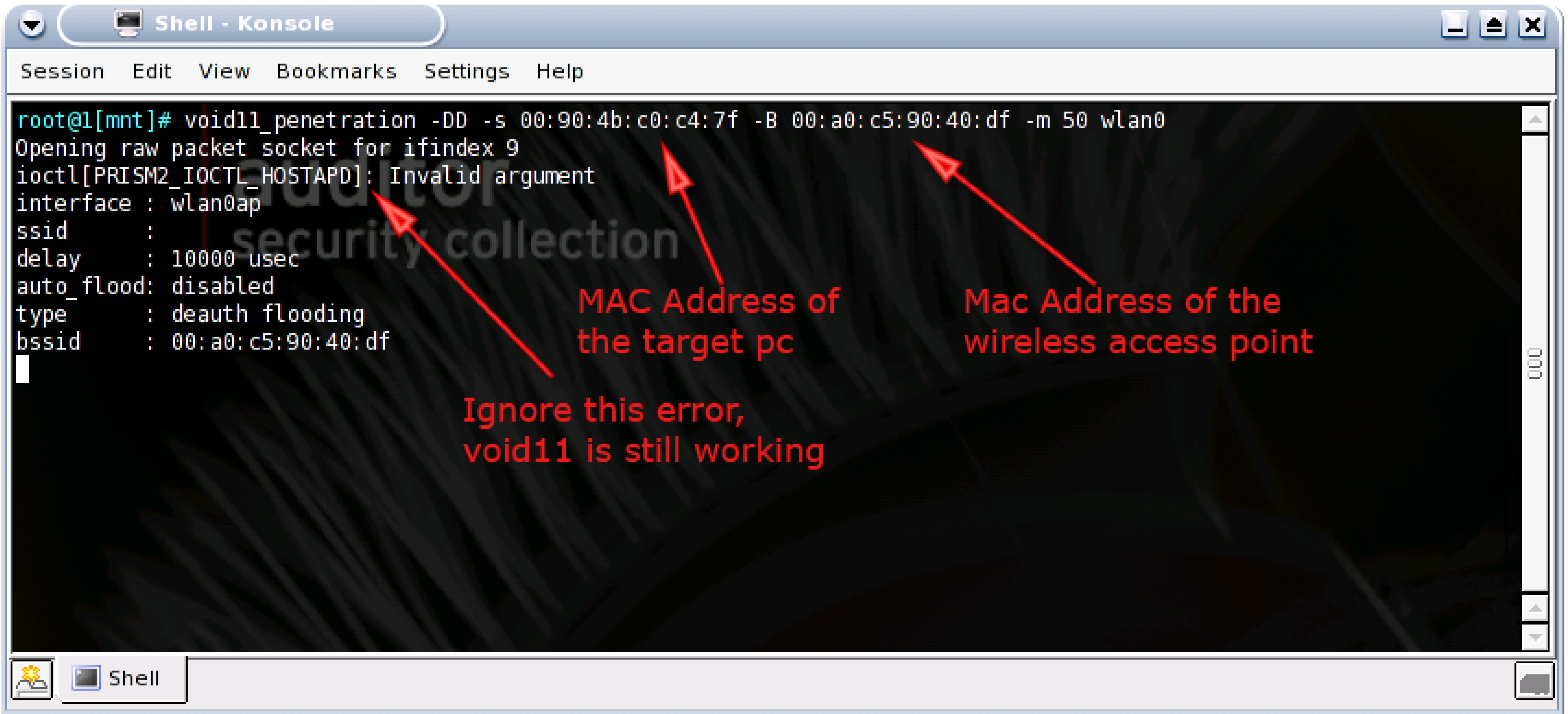
Dumping packets (IVs) - airodump



Number of needed packets

- 64bits WEP key : ~ 50 000 – 200 000 IVs
- 128bits WEP key : ~ 200 000 – 700 000 IVs

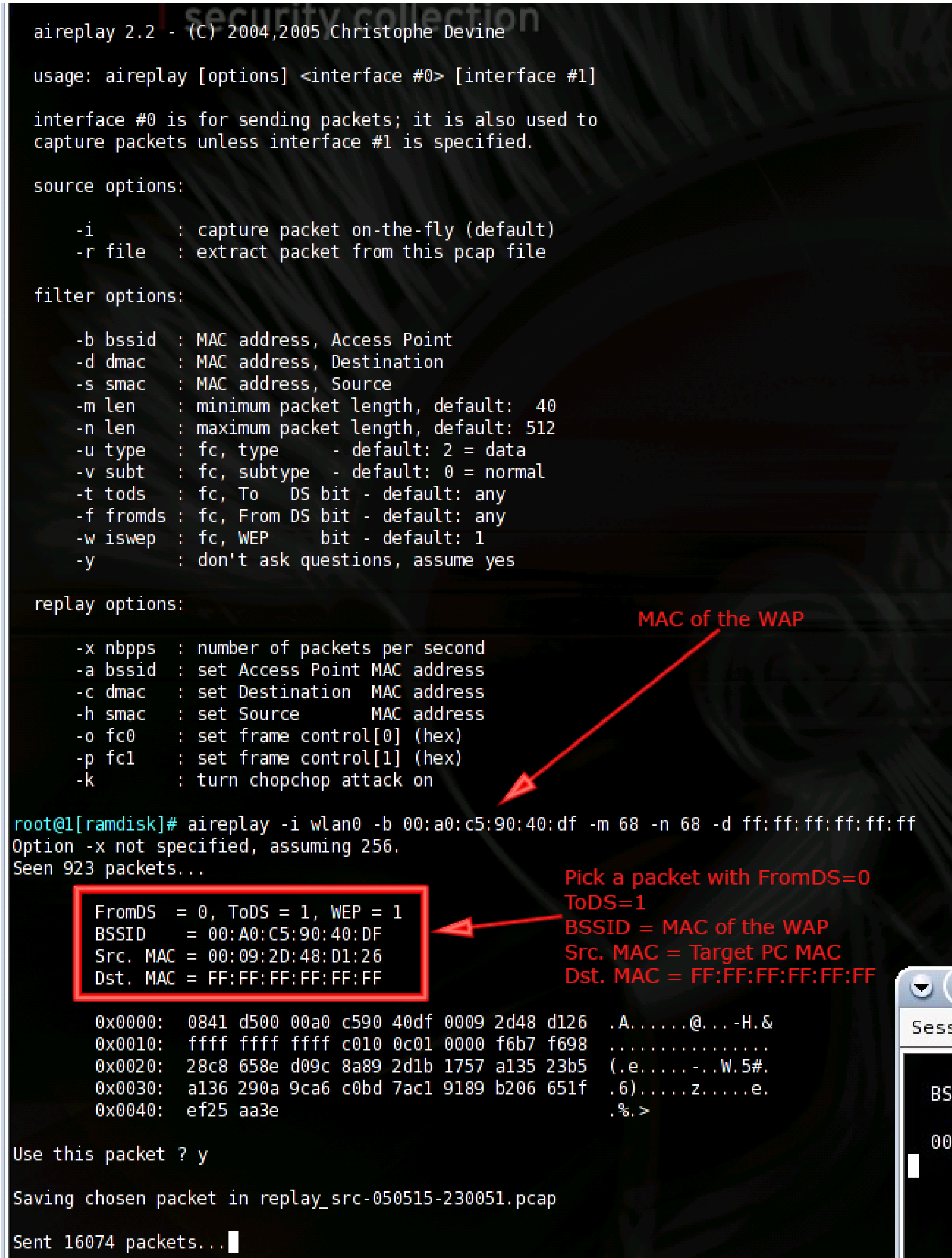
Active attack – void11



Very noisy !

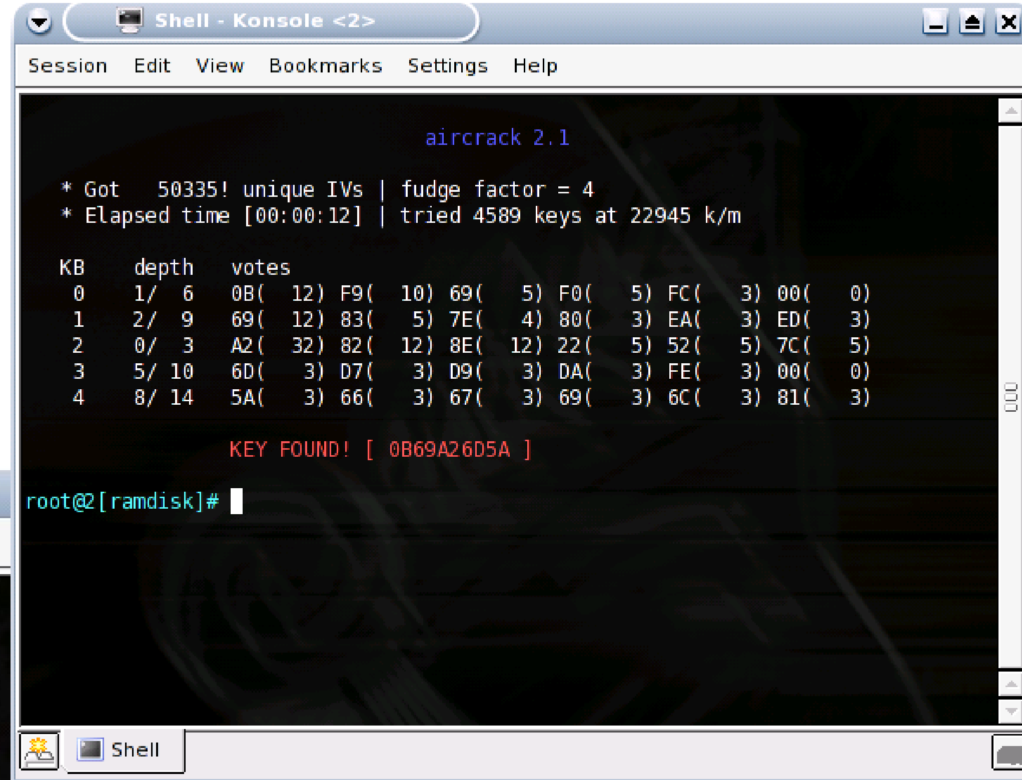
~ 100 IVs generated per second

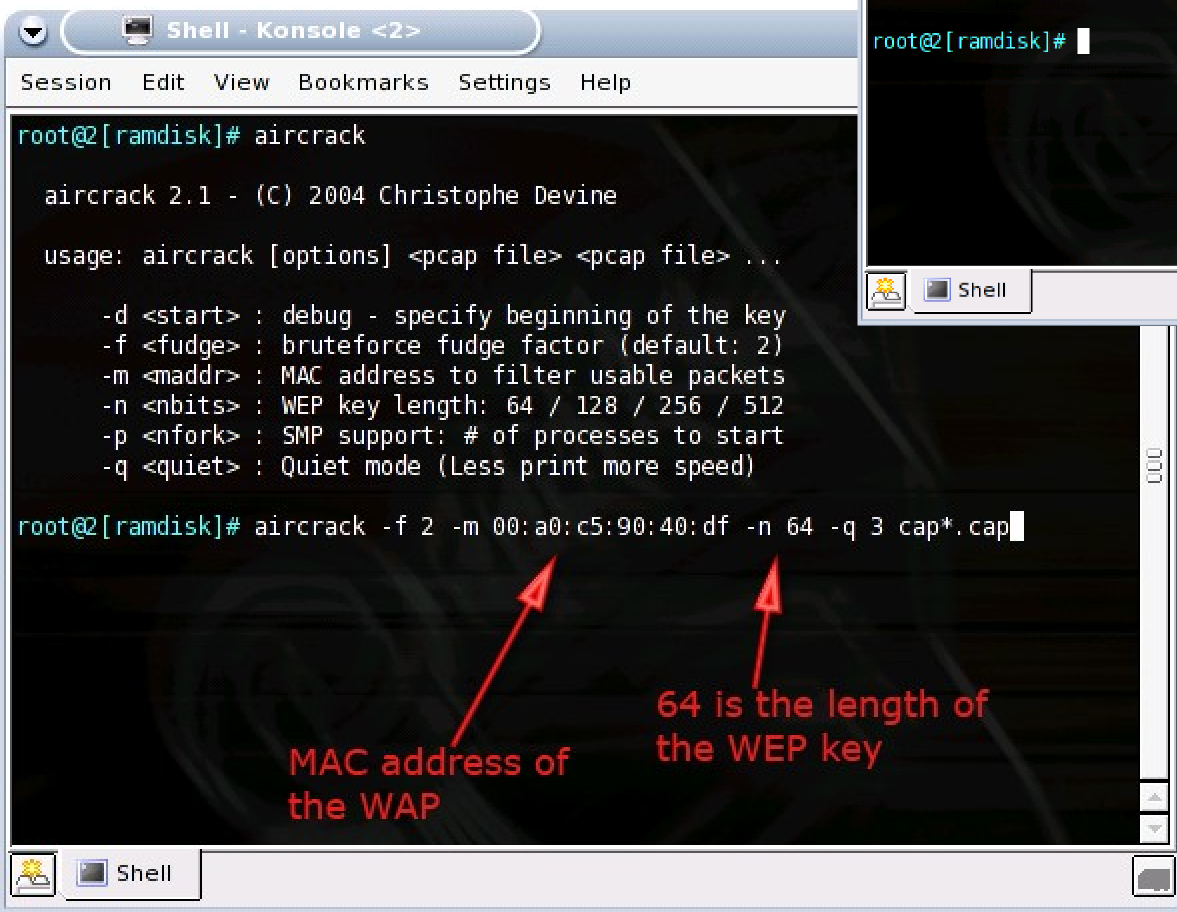
Stealth attitude – aireplay



Packet capture (ARP)
Re-send while masquerading as the target
around 200 IVs per second

Last touch – aircrack





Crypto. attack against RC4 (Fluhrer, Mantin, Shamir)
aircrack-ptw (better?)
WEP : K.O. (1min 3s?)

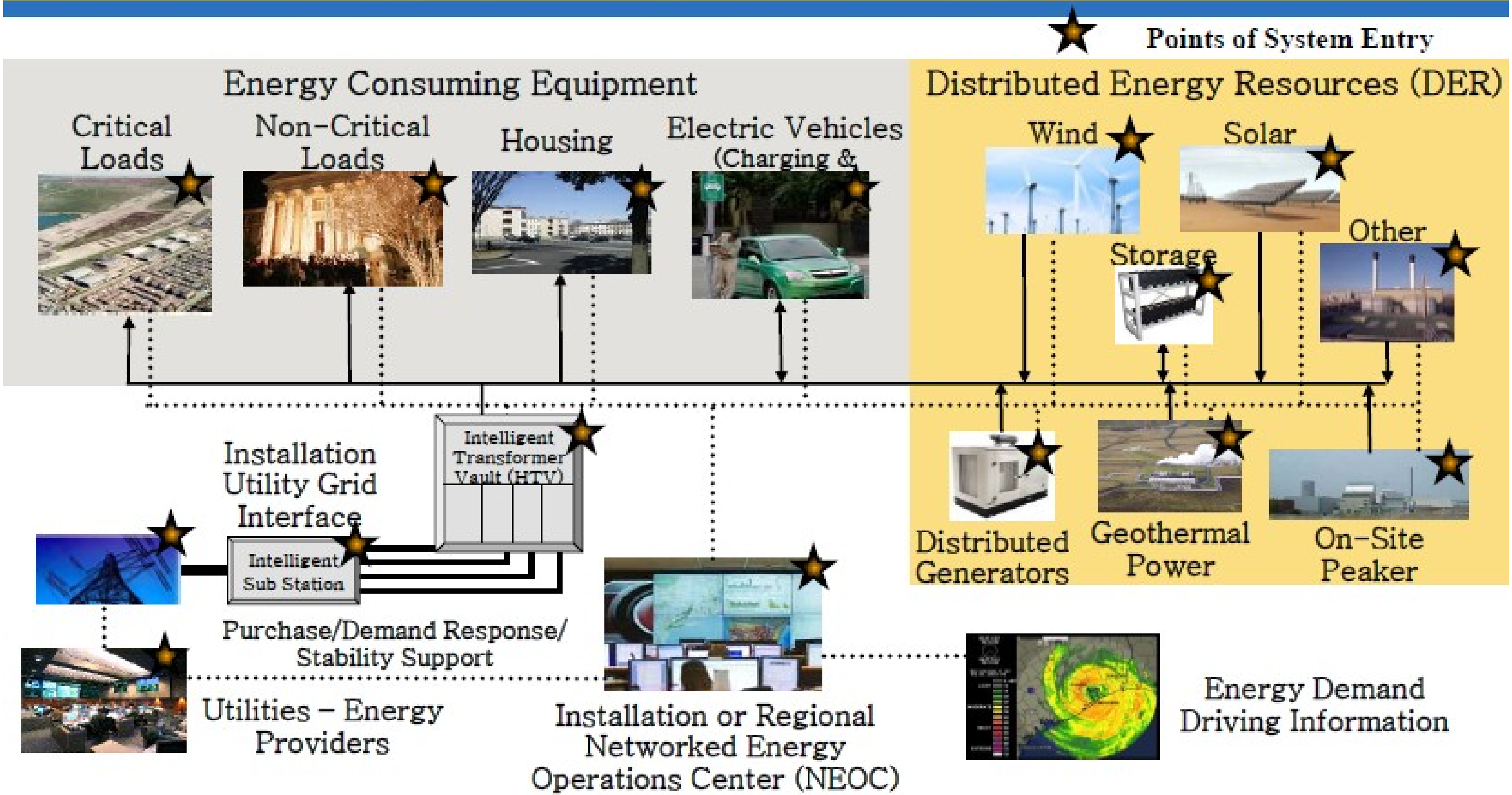
Overall presentation (2/2)

- Case studies
  - Wireless networks
  - **New generation avionics systems - Industrial systems**
  - Network appliances
  - Mobile telephony
  - Gaming devices
- Wrap-up (on-demand)
  - IDS
  - Firewalls
  - Tripwire
  - Metasploit
  - Anti-virus

Other industrial systems first

- Shodan exposes SCADA systems
  - Simple web scanner for common apps.
  - www.shodanhq.com
- False Illinois Water Pump Hack Case
  - Actual system lack of security guarantees
  - A no-event in practice
    - Legitimate connection from a sub-contractor (from a russian location)
    - False assumption of SCADA hacking
  - But nobody checked with nobody
  - Finger-pointing ≠ security

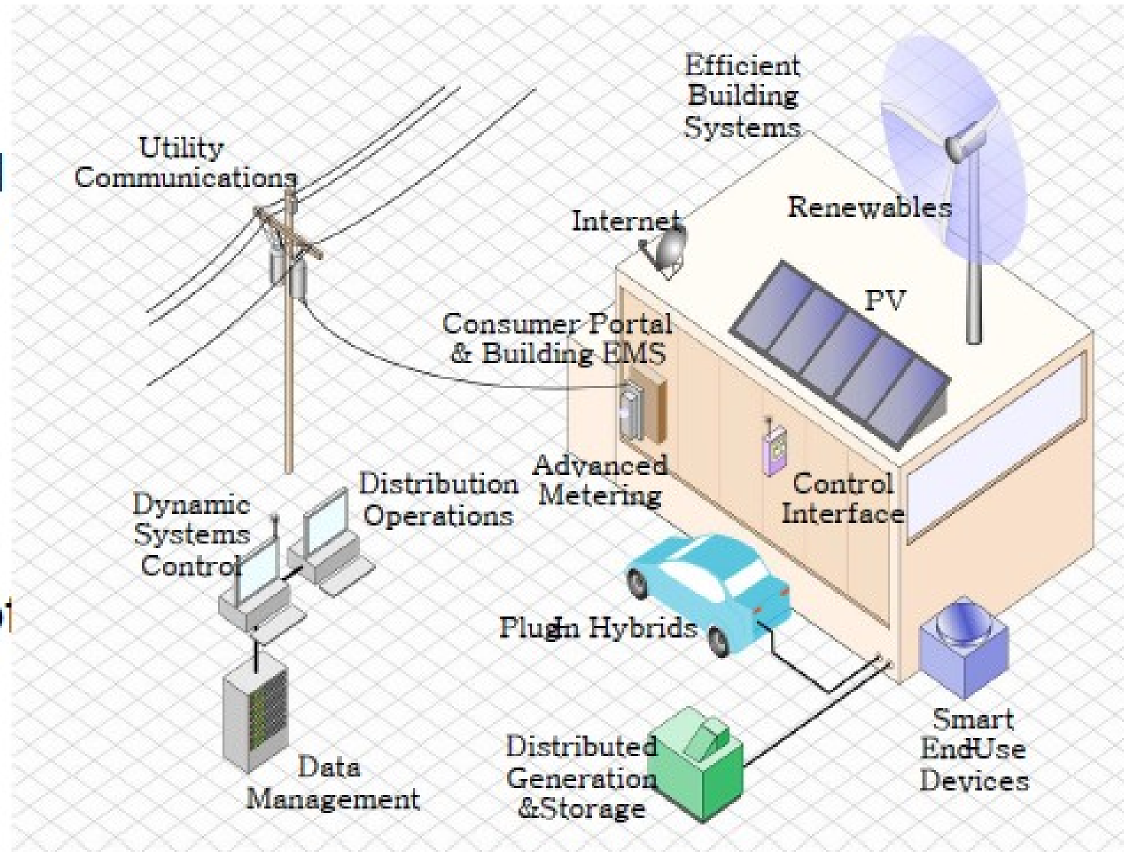
Smart grid security



William Hunteman, U.S. Dept. of Energy, 1 march 2011.

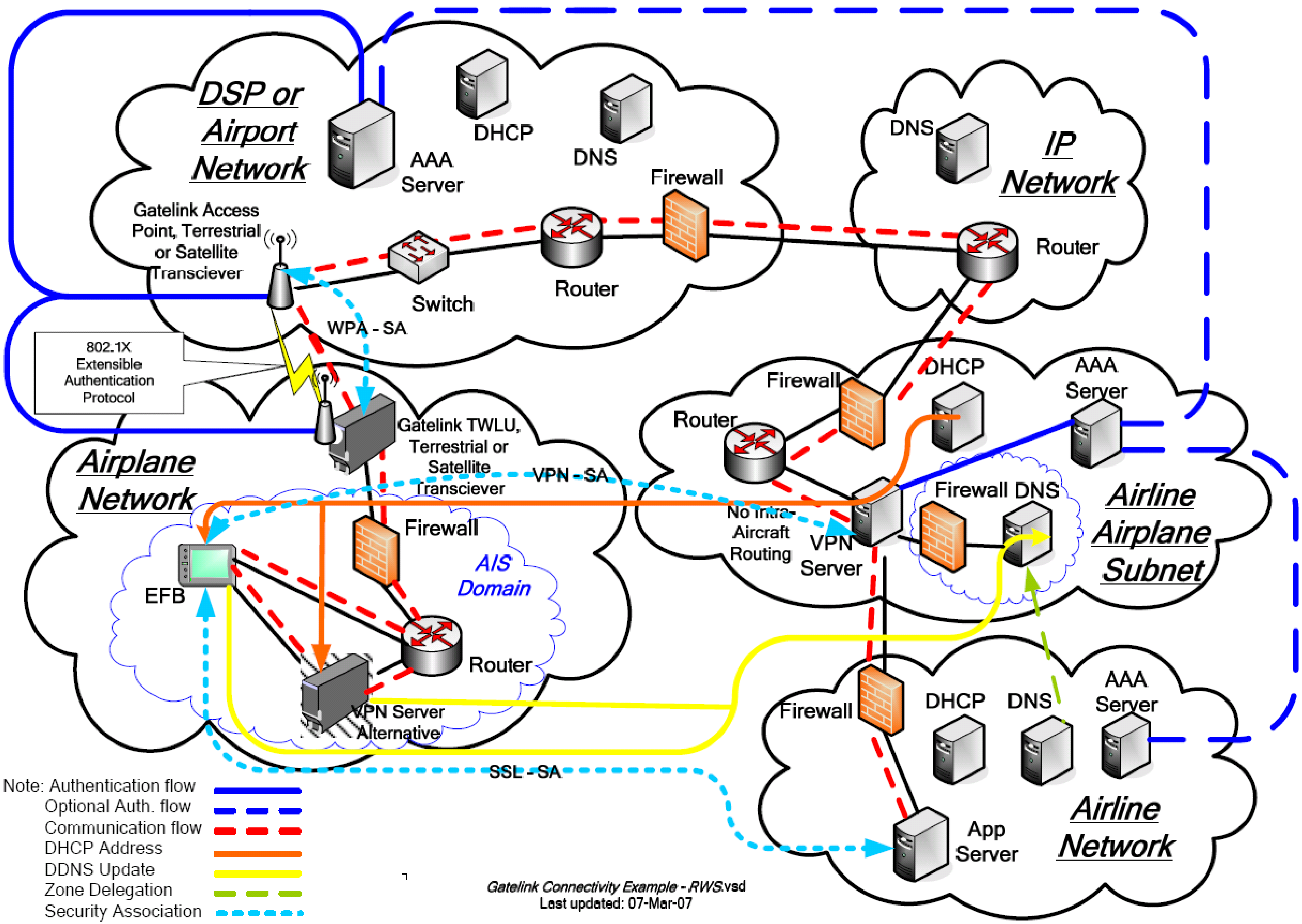
Smart grid security

- Increasing interconnections at all levels
- Adoption of standardized technologies with known vulnerabilities
- Connectivity of control systems to other networks
- Insecure connections
- Widespread availability of technical information about control systems
- Increasing reliance on automation



William Hunteman, U.S. Dept. of Energy, 1 march 2011.

Overall avionic domain schema (for DNS)



AFDX & co.

- Avionics network
  - based on Ethernet (10/100 Mb/s)
  - fully switched
  - redundancy (2x)
  - circuits available (with guaranteed transit time)
    - VL : virtual links, multicast (1 to n)
    - Statically preconfigured (including dest. port)
    - VLid : 16 bits in the MAC Dest. Adress.
  - *network filtering (including over circuits)*
    - *or not specifically?*
  - ICMP, SNMP (TCP) on-board

AFDX Evolutions

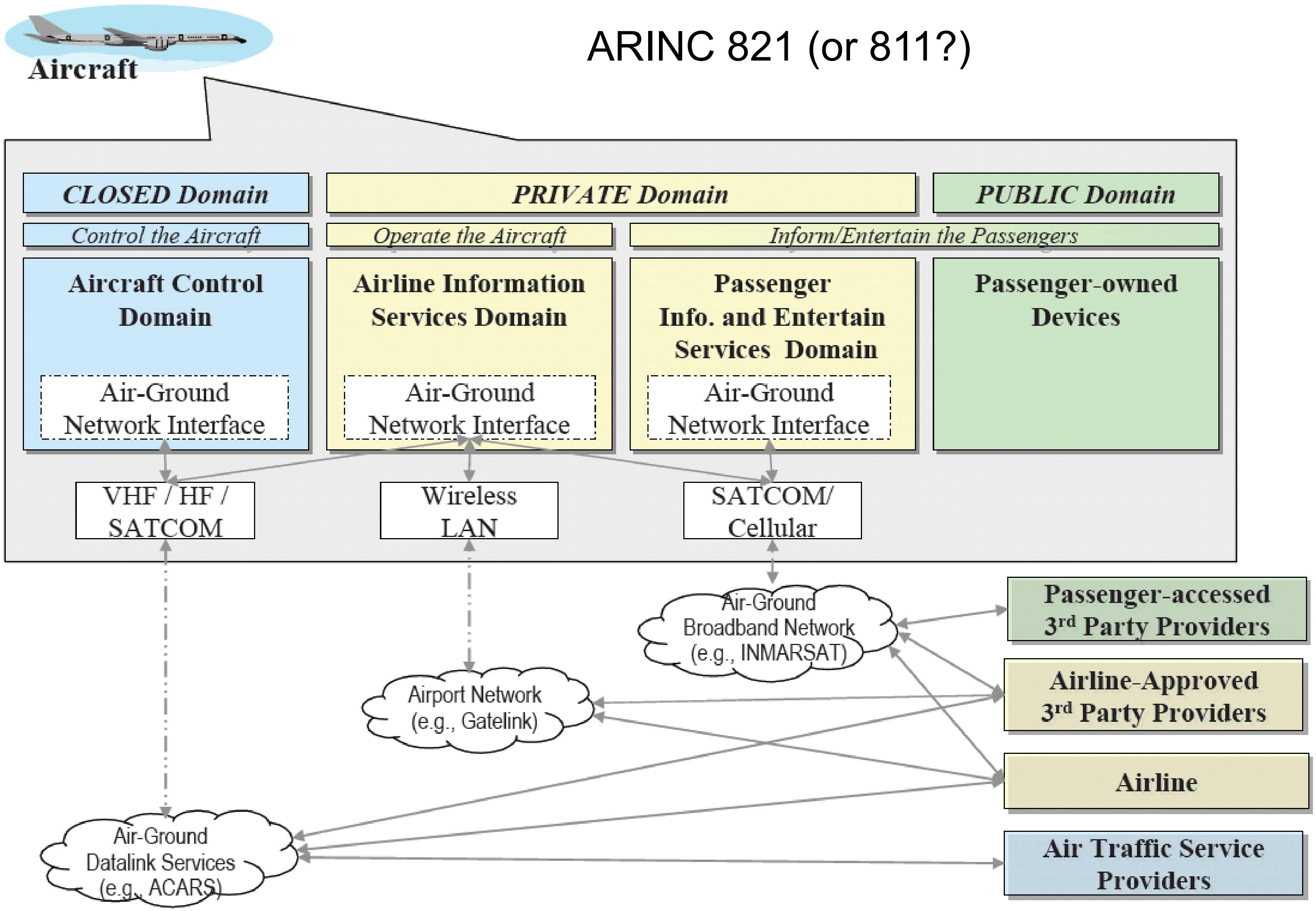
- Known
  - Increase bandwidth
- Unknown
  - Mix operational and service trafic
  - Remove gateway function
    Replace autoSAR

← *Advertisement goes here*

- Volpe Center
- ATA Gatelink

The ARINC model

ARINC 821 (or 811?)



DOT/FAA/AR-08/31

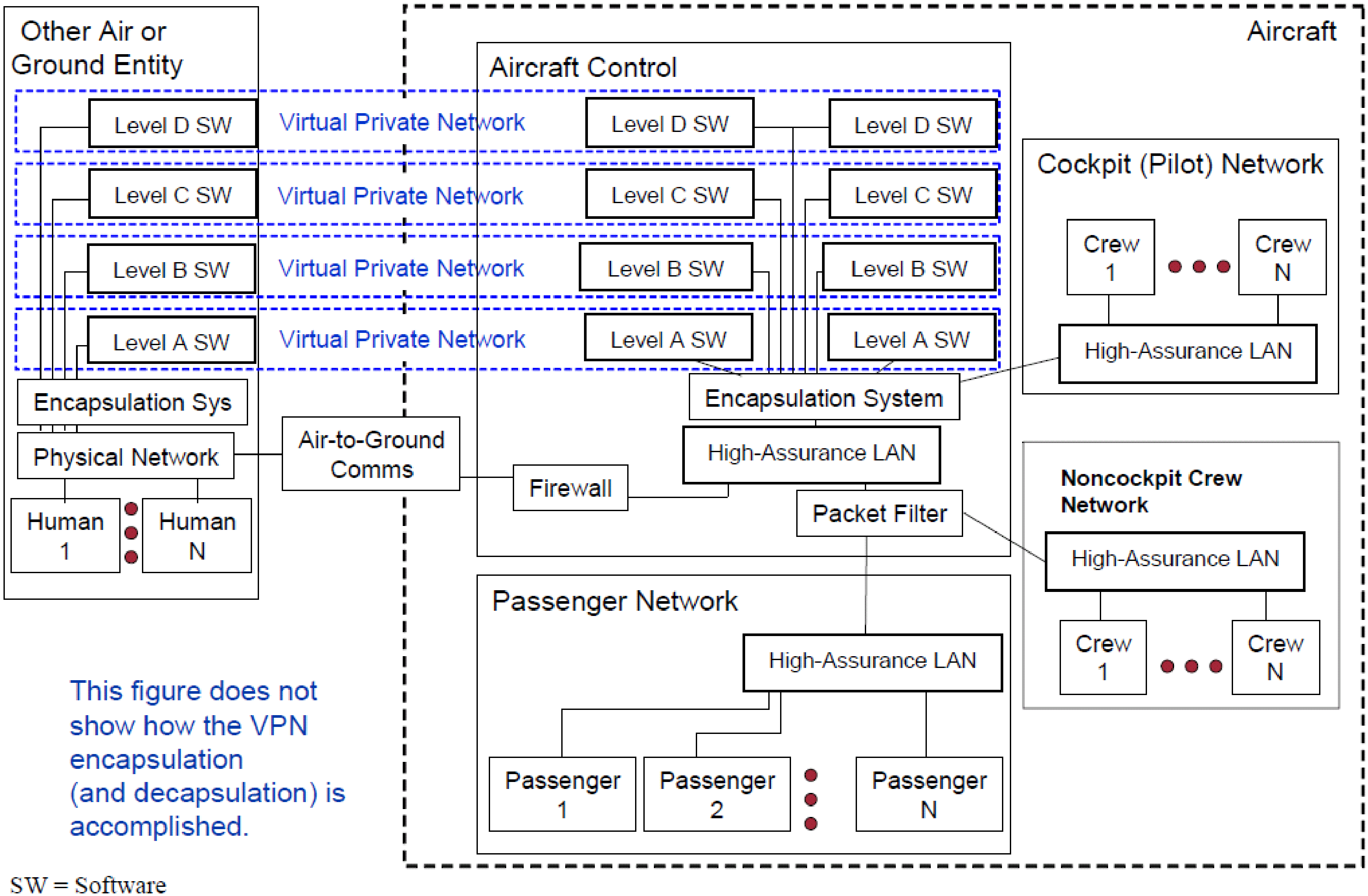


Figure 30. Secure Generic Airborne Network Design (High-Level View)

DOT/FAA/AR-08/31

Figure 31 shows how the recommended architecture addresses many of the network risks that were previously discussed in section 4.

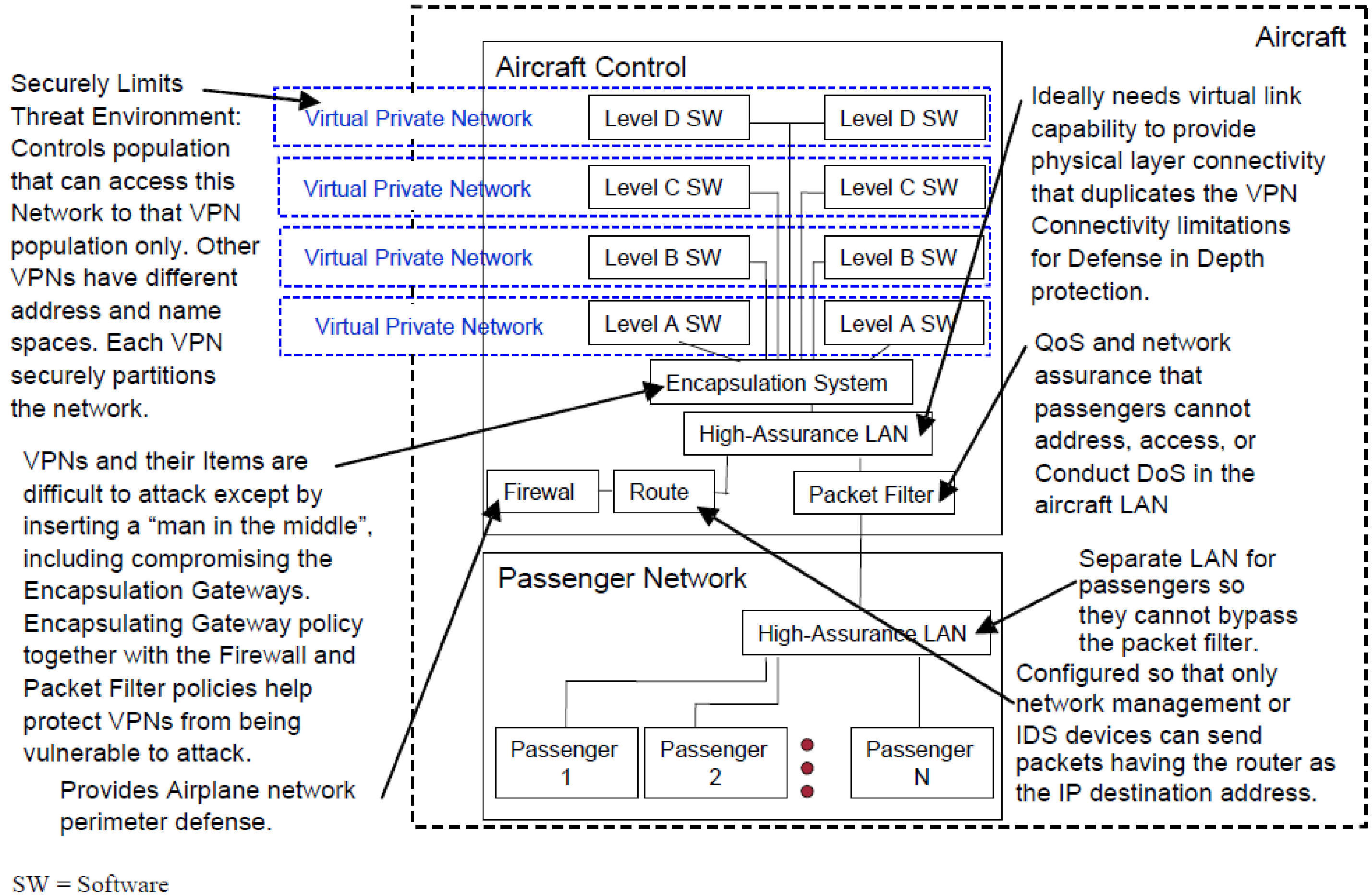
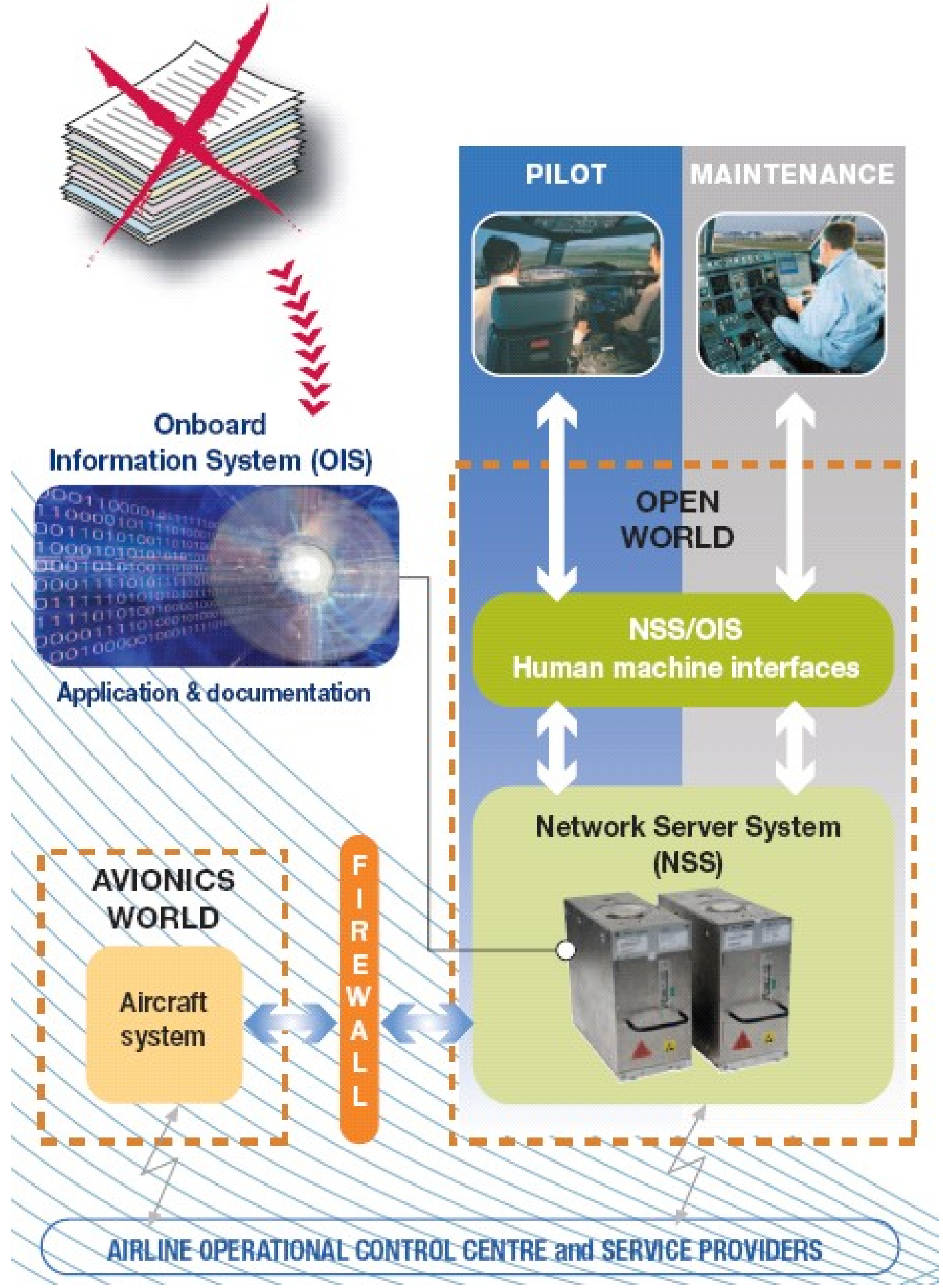


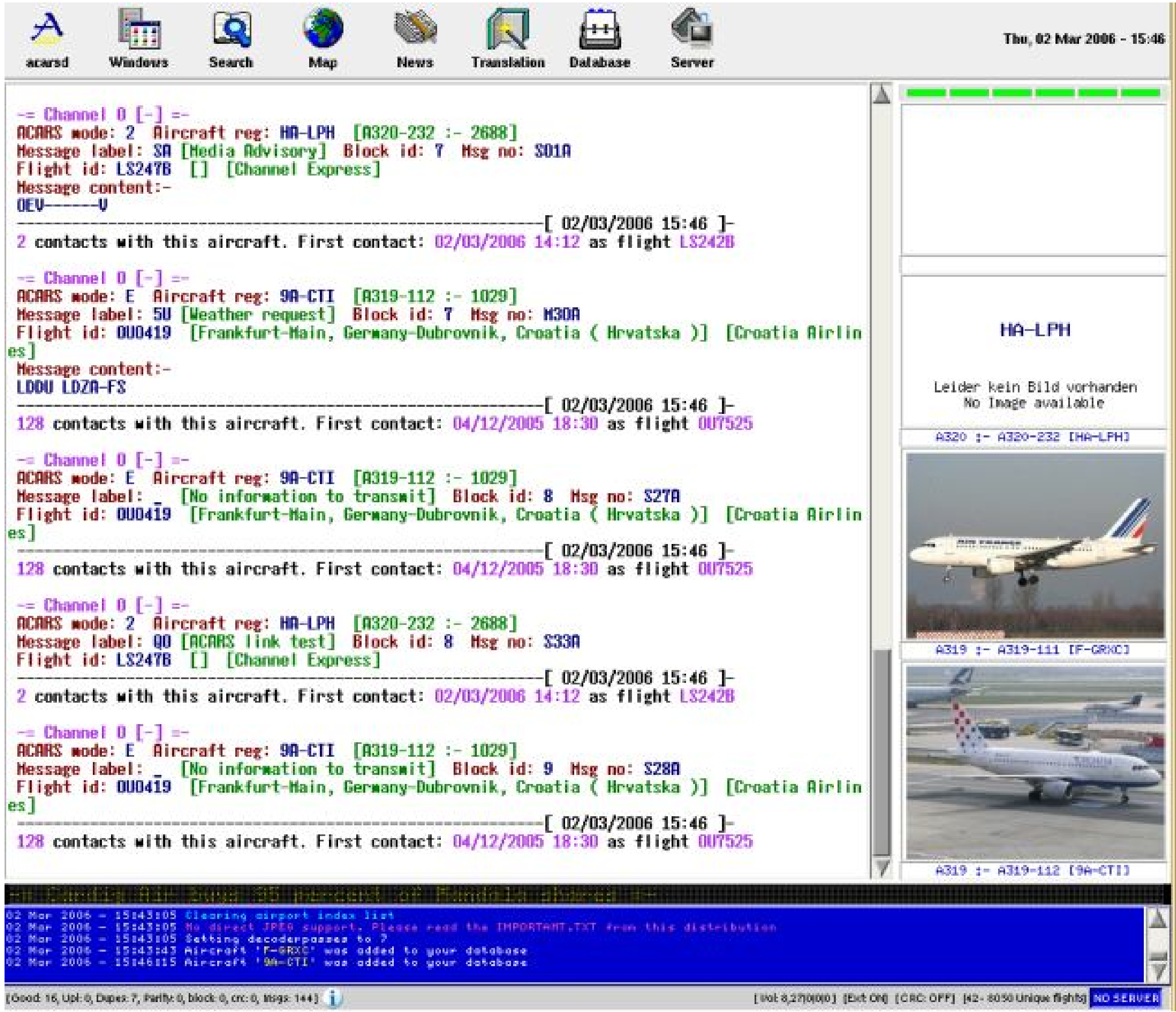
Figure 31. How Design Addresses Network Risks

Airbus flyer



«Highly specific» technology
1978-20xy ?

- www.acarsd.org



Overall presentation (2/2)

- Case studies
  - Wireless networks
  - New generation avionics systems
  - **Network appliances**
  - Mobile telephony
  - Gaming devices
- Wrap-up (on-demand)
  - IDS
  - Firewalls
  - Tripwire
  - Metasploit
  - Anti-virus

Network *appliances*

- A common type of embedded systems
  - routers, switches
  - ADSL boxes
  - WiFi stations
  - ...
- Cisco OS
  - PIX
  - IOS

A thrilling story

- 2002, Black Hat, Defcon X, other things
- Summer 2005, Black Hat conference
  - ***The Holy Grail: Cisco IOS Shellcode And Exploitation Techniques***
    - **Michael Lynn**, ISS
  - Cisco and ISS do act
    - complaint
    - on-site action (proceedings confiscated)
  - Michael Lynn, ex-ISS, speaks anyway
- November 2005
  - patch published by Cisco

Random thoughts (true or false)

- Routers and switches use off-the-shelf CPU to run their software
  - hardware is not alone
- There are buffers and they overflow
  - there are no buffers overflow
- You cannot exploit them
  - you can exploit them
- Such exploits are portable
  - each piece of hardware is very different

Heavily based on Michael Lynn's Black Hat presentation

IOS Basics

- Monolithic OS
  - no dynamic modules
  - all adresses are static
  - adresses differ from one build to another
- Realtime OS
  - as soon as you execute you control the CPU
  - exit cleanly (or fail miserably)
  - as soon as you execute you can keep the CPU
- Stability is valued over everything else
  - IOS would rather reboot than correct errors

Code quality

- Much better than on other platforms
  - Heap internal integrity checks
  - Overflow runtime checks
  - Stack is rarely used
  - A process checks heap integrity
  - Very old code, very tested
- There are still bugs
  - But you need a lot of imagination

The Dreaded Check Heaps Process

- Constantly walks the heap to spot bad links
  - Even for unfreed entries, it detects incorrect links
  - Executes every 30 or 60 seconds, depends on load
- It is the primary reason why heap overflow exploits are so hard

Defeating the protection

- Code dissassembly
- Lots of time and energy
- Few known tricks
  - pointers exchange
  - heap overflow
- Defeating the heap check process
  - Simulate a reboot (altering abort())
  - a CPU watchdog will kill the heap check process
- Use the available time to complete the exploit

Impact?

- Cisco probably had a hard time
- A generic worm would have been very hard to develop
  - static adresses
  - a lot of different images in production

- But..., some also thought to
  - the Titanic
  - or Pearl Harbor

Overall presentation (2/2)

- Case studies
  - Wireless networks
  - New generation avionics systems
  - Network appliances
  - **Mobile telephony**
  - Gaming devices
- Wrap-up (on-demand)
  - IDS
  - Firewalls
  - Tripwire
  - Metasploit
  - Anti-virus

Mobile telephony (*before*)

- Windows CE (Microsoft)
- Symbian (Nokia)

- *open-source* (as much as possible)
  - Qtopia (TrollTech)
  - Android (Google, Motorola)
  - OpenMoko, OpenEmbedded (Sean, Koen, Harald, Mickey, etc.)

Symbian Devices

Source : Nokia Course Pack 04300, v3.0

~~Mobile telephony~~ (*now*)

- Apple iPhone
- Google Android

- Not a phone anymore : a computer
  - a really portable one

Android & the Droids

- Linux kernel-enforced sandboxing
  - Lots of « permissions » to request (refuse?)
- Application signing
  - Signature-level permissions
- User IDs and file-access
  - 2 applications have 2 UIDs
  - and/but there is « shareUserID »
- Declaring and enforcing permissions
  - Via the androidManifest.xml
- and per-URI permissions

Real-world usage examples?

Mobilife

- www.ist-mobilife.org
- IST-FP6 project (2004-2006)
- End users needs
  - context awareness
  - group management
  - etc. (multimodal interactions, localization, ...)
- Reference architecture
  - ...
  - privacy & trust
  - group management

TCG – Mobile Phone Use Cases (1/3)

- Platform integrity
  - Devices possess and run only authorized operating systems and hardware
- Device authentication
  - to assist in user authentication (hold keys)
  - prove the identity of the device itself
- Robust DRM implementation
- SIMLock / Device Personalisation
  - device remains locked to a particular network

TCG – Mobile Phone Use Cases (2/3)

- Secure software download
  - application, patches, firmware updates, etc.
- Secure channel between device and UICC
  - Some security sensitive applications may be implemented partly in the UMTS Integrated Circuit Card (UICC) and partly in the device.
  - Sensitive (e.g. provisioning) data echange
- Mobile ticketing
- Mobile payment
- Software use (security policies)

TCG – Mobile Phone Use Cases (2/3)

- Proving platform and/or application integrity to end user
  - The end user wants to know that a Device or application can be trusted
- User Data Protection and Privacy
  - Personally identifiable information
  - Contact /Address books
  - Wallets, credentials, identity tokens

GSM Security

- An old affair ?

- Not so good
  - http://laforge.gnumonks.org/weblog/gsm/
  - The network does not authenticate to the phone
  - A5 « private » ciphers family issues

BYO SMS jamming

- « Blowing up the Celly »
  - PacSec 2014, DEFCON 22
  - Brian Gorenc, Matt Molinyawe (HP)
- OpenBTS-based
- RF test enclosure needed
- phone == target

Needed hardware

Our Bill of Materials

USRP and Accessories
USRP N210 Kit (782747-01) - $1,717.00
WBX-40 USRP Daughterboard - $480.00
USRP GPS-Disciplined Oscillator Kit - $758.00
SMA-to-SMA Cable Assembly - $30.00
VERT900 Vertical Antenna Dualband - $35.00
Total: $3,020.00

Cell Phones and SIMs
Unlocked Phones ~ $500
Pre-paid SIMs ~ $10-$20
Micro SIM Cutter Tool ~ $5
Total: ~$550

RF Enclosure and Accessories
STE3000FAV - $2,495.00
SMA Feedthrough Connectors
DB9 10 PF and DB9 100 PF Connectors
USB, RJ45 Adapter Kits
Total: $3,096.00

Overall presentation (2/2)

- Case studies
  - Wireless networks
  - New generation avionics systems
  - Network appliances
  - Mobile telephony
  - **Gaming devices**
- Wrap-up (on-demand)
  - IDS
  - Firewalls
  - Tripwire
  - Metasploit
  - Anti-virus

Gaming devices (>2000)

- Anti-piracy features
- Supplier-controlled software signature
- Protection architecture using hardware components (*hidden ROM*)
- XBOX example
  - Public key in PROM, private key at Bill's
  - Integrity checks starting from boot
  - Attack
    - *reverse engineering* and ROM exchange
    - Using James Bond, a *Mech* or a *sniper*... (third party vulnerable code)
- Sony problems

www.xbox-linux.org

... *a princess...* **www.wiibrew.org**

Next step

- Multilevel security policy and mandatory access control ?
  - on a gaming device?
  - on a home video recorder? (Philips, DRM)

- OpenBSD : Old style (or not)?

BadUSB

- SecurityResearchLabs study
  - Karsten Nohl, Sascha Krißler, Jakob Lell
  - PacSec Applied Security Conference

BadUSB

- USB devices include a micro-controller and possibly flash storage
- Large family of possible attacks
  - Emulate keyboards
    - Device deregisters then register again as a different one
  - Spoof network card
    - DHCP magic overrides DNS or default gateway
  - « USB boot-sector » virus
  - *Hide data on stick of HDD*
  - *Rewrite data in-flight*
  - *Update PC BIOS*
  - *Spoof display*

BadUSB

- Small hardware differences can detemine vulnerability
  - Especially flash presence
- Exposure is probably growing
  - More devices, more complex and more programmable
- Effective defenses are missing
  - Simple ones (disable updates in hardware) are limited to new non upgradable devices
  - Secure crypto. sounds overkill for microcontrollers (though security guys may disagree)
  - Firmware scanning... can of worms
- **No responses**
  - Chip, peripheral or OS vendors alike

Overall presentation (2/2)

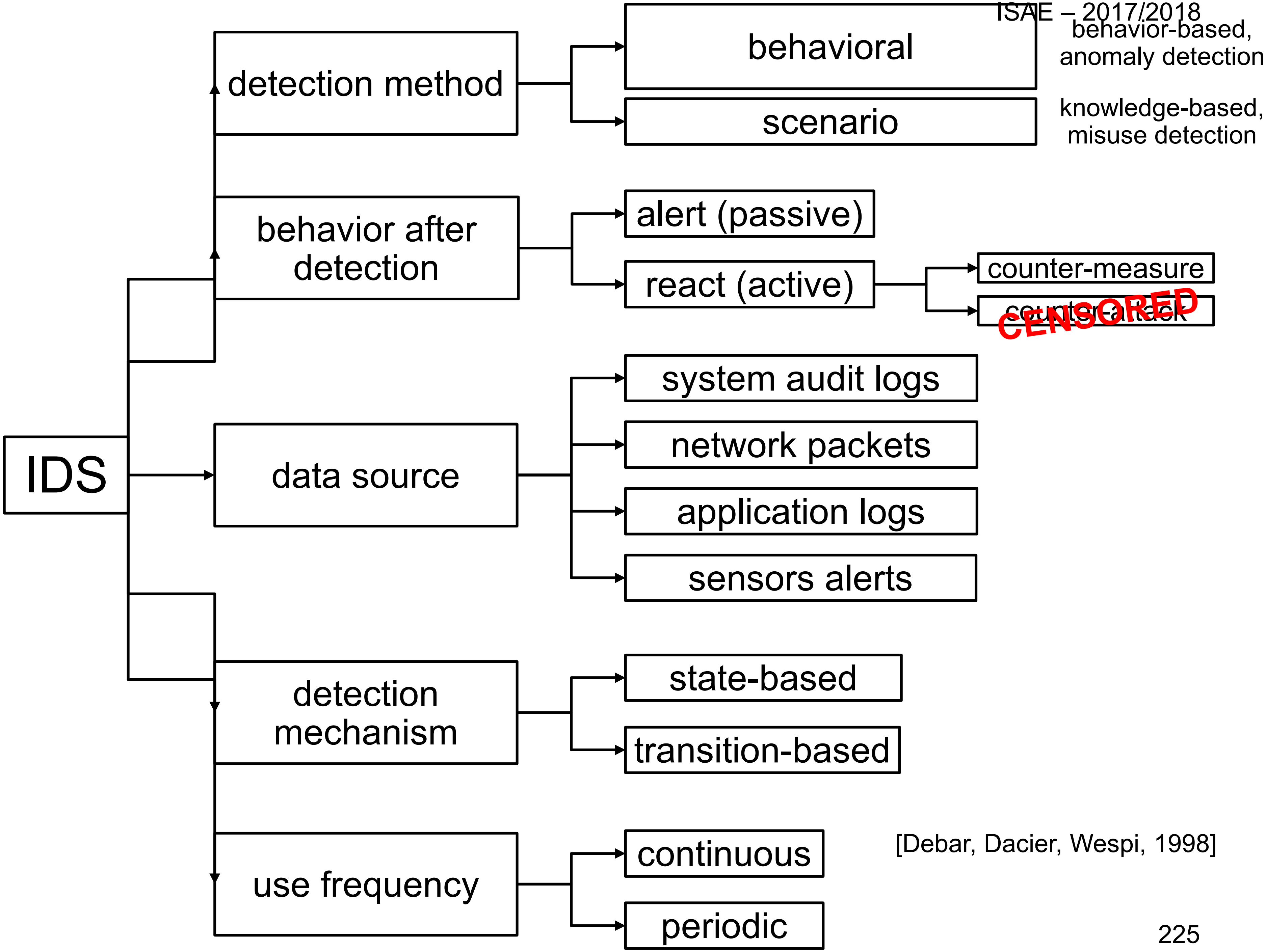
- Case studies
  - Wireless networks
  - New generation avionics systems
  - Network appliances
  - Mobile telephony
  - Gaming devices
- Wrap-up (on-demand)
  - **IDS**
  - Firewalls
  - Anti-virus

Vulnerabilities – Attacks – Alerts

- Vulnerabilities
  - Many types : *buffer overflow*, CGI, permissive access rights, network session hijacking, privilege transfers, *social engineering*, cryptanalysis, etc.
- « Attack »
  - Exploitation of a single vulnerability
  - Elementary attack or intrusion scenario
  - Malicious vs. suspicious action
- Alerts
  - Message sent after detection of an attack
  - *IDMEF (XML): Intrusion Detection Message Exchange Format défini par l'IETF/IDWG*

Alert generation (efficiency)

	No alert	Alert
No attack	True negativef ☺	False positive ☹
Ongoing attack	False negative ☹	True positive 😐



[Debar, Dacier, Wespi, 1998]

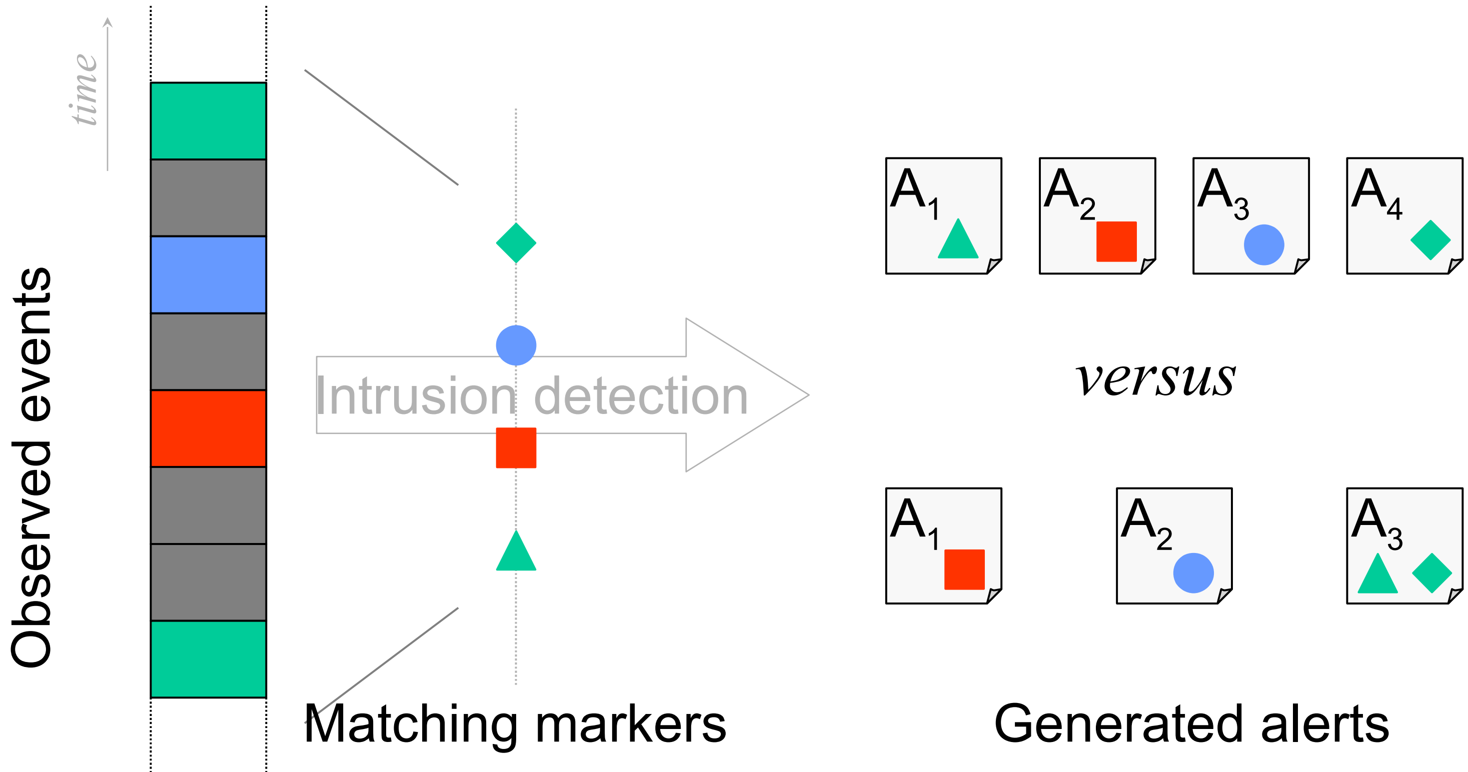
Usable techniques

- Scenario-based approaches
  - Expert system (ES)
  - Signature analysis (SA)
  - Petri nets (PN)
- Behavioral approaches
  - Statistical (ST)
  - Expert system (ES)
  - Neural networks (NN)
  - Immunological approach (UII)

Current trends

- A single technique per tool, usually
- Signatures-based techniques domine
    - Simpler implementation
    - Performances
- Behavioral approaches are seldomly used in commercial tools
- Reactive functions appear

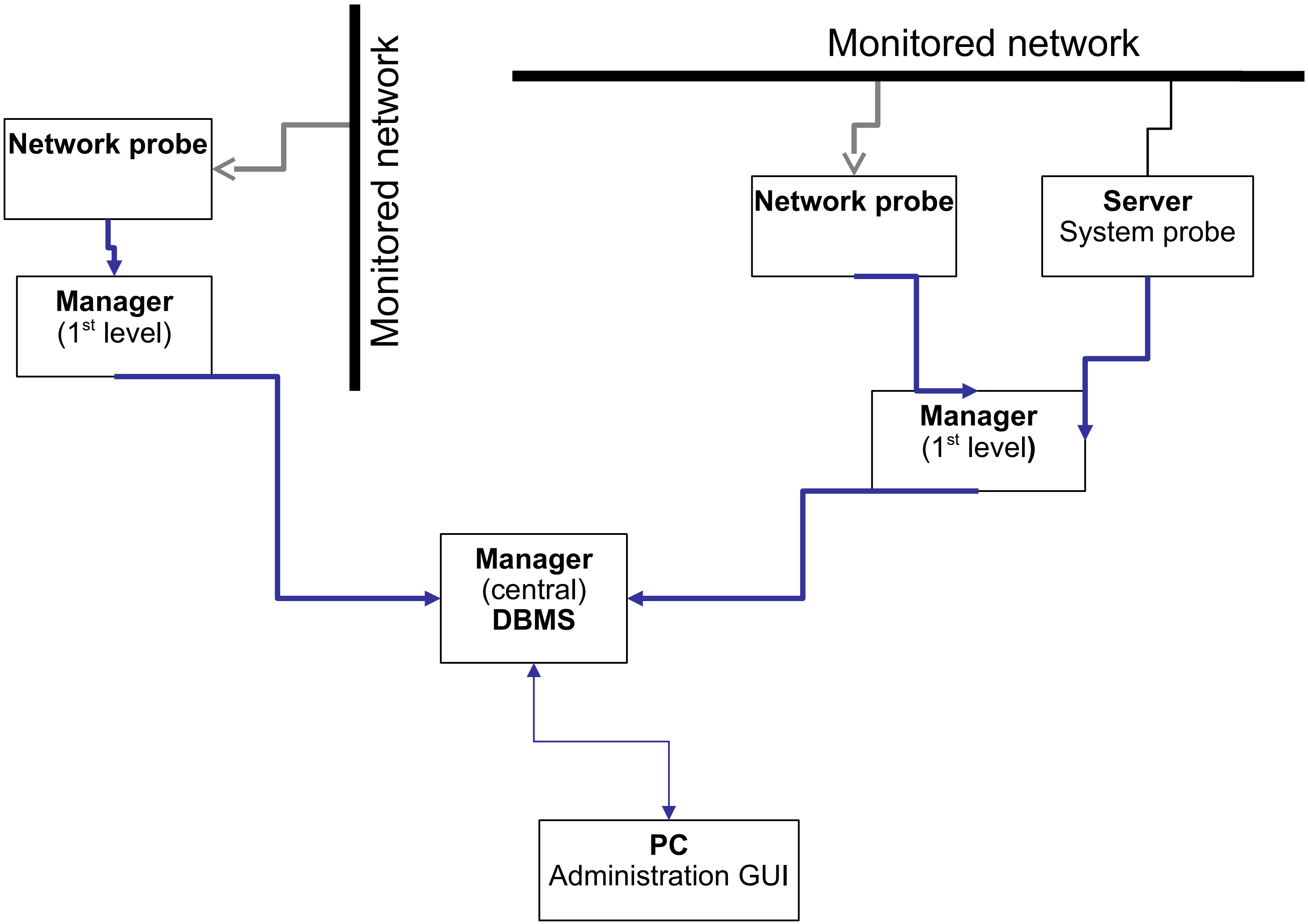
Multi-event analysis



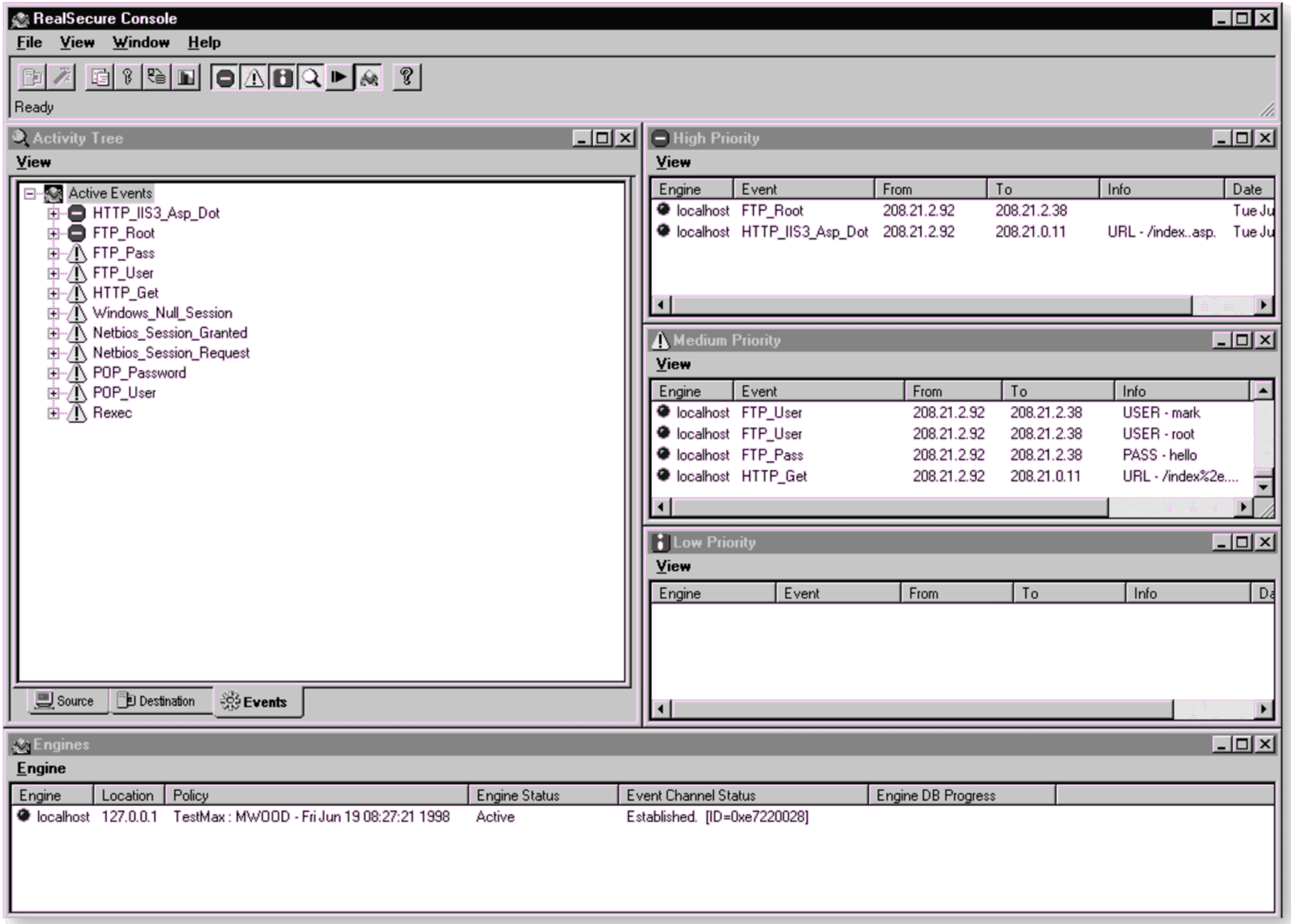
Implementation considerations

- Probes
  - (Network) Monitoring
    - Situation choice
    - Issues with switched Ethernet (*mirroring* vs. *taps*)
  - System probes
  - Signature number (and CPU usage)
  - Signature accuracy and relevance
- Alerts management
  - Collectors
  - Secure exchange protocol
  - IDMEF exchange format (RFC 4765 plus 4766 & 4767)

Possible architecture



Ex. : ISS RealSecure GUI



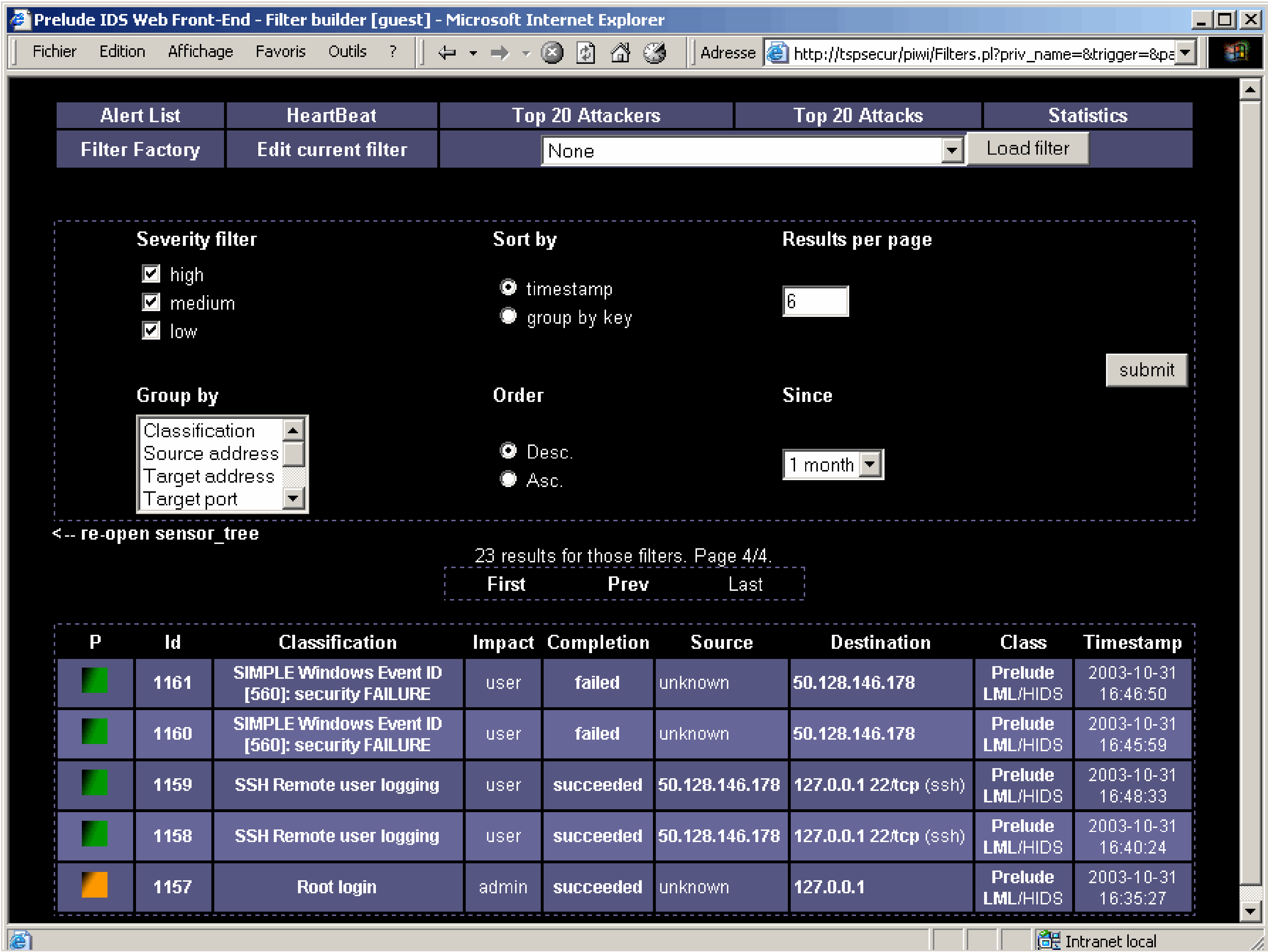
Signatures – Snort (1)

SID	1800
Message	VIRUS Klez Incoming
Signature	alert tcp $EXTERNAL_NET any -> $SMTP_SERVERS 25 (msg:"VIRUS Klez Incoming"; flow:to_server,established; dsize:>120; content:"MIME"; content:"VGhpcyBwcm9"; classtype:misc-activity; sid:1800; rev:3;)
Summary	This event is generated when an incoming email containing the Klez worm is detected.
Impact	System compromise and further infection of target hosts.
Detailed Information	W32/Klez.h@MM exploits the vulnerability in Microsoft Internet Explorer (ver 5.01 or 5.5 without SP2), enabling it to execute email attachments. Once executed, it can unload several processes including Anti-virus programs. The worm is able to propagate over the network by copying itself to network shares (assuming sufficient permissions exist). Target filenames are chosen randomly, and can have single or double file extensions.
Affected Systems	Microsoft Internet Explorer (ver 5.01 or 5.5 without SP2)
Attack Scenarios	This virus can be considered a blended threat. It mass-mails itself to email addresses found on the local system, then exploits a known vulnerability, spreads via network shares, infects executables on the local system.
Ease of Attack	Simple. This is worm activity.
False Positives	Certain binary file email attachments can trigger this alert.
False Negatives	None known.
Corrective Action	Apply the appropriate vendor suppled patches. Block incoming attachments with .bat, .exe, .pif, and .scr extensions
Contributors	Sourcefire Research Team Brian Caswell <bmc@sourcefire.com>

Signatures – Snort (2)

<table>
<tr><th>SID</th><td>2251</td></tr>
<tr><th>Message</th><td>NETBIOS DCERPC Remote Activation bind attempt</td></tr>
<tr><th>Signature</th><td>alert tcp $EXTERNAL_NET any -> $HOME_NET 135 (msg:"NETBIOS DCERPC Remote Activation bind attempt"; content:"|05|"; distance:0; within:1; content:"|0b|"; distance:1; within:1; byte_test:1,&,1,0,relative; content:"|B8 4A 9F 4D 1C 7D CF 11 86 1E 00 20 AF 6E 7C 57|"; distance:29; within:16; reference:cve,CAN-2003-0352; classtype:attempted-admin; reference:url,www.microsoft.com/technet/security/bulletin/MS03-026.asp; reference:cve,CAN-2003-0715; sid:2251; rev:1;)</td></tr>
<tr><th>Summary</th><td>This event is generated when an attempt is made to exploit a known vulnerablity in Microsoft RPCSS service for RPC.</td></tr>
<tr><th>Impact</th><td>Denial of Service. Possible execution of arbitrary code leading to unauthorized remote administrative access.</td></tr>
<tr><th>Detailed Information</th><td>A vulnerability exists in Microsoft RPCSS Service that handles RPC DCOM requests such that execution of arbitrary code or a Denial of Service condition can be issued against a host by sending malformed data via RPC.

The Distributed Component Object Model (DCOM) handles DCOM requests sent by clients to a server using RPC. A malformed request to the host running the RPCSS service may result in a buffer overflow condition that will present the attacker with the opportunity to execute arbitrary code with the privileges of the local system account. Alternatively the attacker could also cause the RPC service to stop answering RPC requests and thus cause a Denial of Service condition to occur.</td></tr>
<tr><th>Affected Systems</th><td>Windows NT 4.0 Workstation and Server
Windows NT 4.0 Terminal Server Edition
Windows 2000
Windows XP</td></tr>
</table>



Prelude IDS Web Front-End - Filter builder [guest] - Microsoft Internet Explorer
Fichier Edition Affichage Favoris Outils ?
Adresse http://tspsecur/piwi/Filters.pl?priv_name=&trigger=&pa
Alert List
HeartBeat
Top 20 Attackers
Top 20 Attacks
Statistics
Filter Factory
Edit current filter
None
Load filter
Severity filter
high
medium
low
Sort by
timestamp
group by key
Results per page
6
submit
Group by
Classification
Source address
Target address
Target port
Order
Desc.
Asc.
Since
1 month
<-- re-open sensor_tree
23 results for those filters. Page 4/4.
First Prev Last
P Id Classification Impact Completion Source Destination Class Timestamp
1161 SIMPLE Windows Event ID [560]: security FAILURE user failed unknown 50.128.146.178 Prelude LML/HIDS 2003-10-31 16:46:50
1160 SIMPLE Windows Event ID [560]: security FAILURE user failed unknown 50.128.146.178 Prelude LML/HIDS 2003-10-31 16:45:59
1159 SSH Remote user logging user succeeded 50.128.146.178 127.0.0.1 22/tcp (ssh) Prelude LML/HIDS 2003-10-31 16:48:33
1158 SSH Remote user logging user succeeded 50.128.146.178 127.0.0.1 22/tcp (ssh) Prelude LML/HIDS 2003-10-31 16:40:24
1157 Root login admin succeeded unknown 127.0.0.1 Prelude LML/HIDS 2003-10-31 16:35:27
Intranet local

Intrusion detection shortcomings (currently)

- Low detection rate
  - False negative alerts
- Too many alerts
  - False alerts : False positive
  - Several thousand alerts per week (busy site)
- Insuficient alert semantic
  - No global view
  - Detection of a distributed attack is very hard
- It is difficult to detect unknown attacks
  - This is an advantage of behavior-based methods

Too many details

Exemple : alertes générées par Dragon

[**] [1:1256:2] WEB-IIS CodeRed v2 root.exe access [**]
07/20-13:59:32.291193 64.165.187.170:4515 -> 193.54.194.111:80
[**] [1:1002:2] WEB-IIS cmd.exe access [**]
07/20-13:59:33.059882 64.165.187.170:4533 -> 193.54.194.111:80
[**] [1:1002:2] WEB-IIS cmd.exe access [**]
07/20-13:59:33.576217 64.165.187.170:4566 -> 193.54.194.111:80

SID	1256
Message	WEB-IIS CodeRed v2 root.exe access
Signature	alert tcp $EXTERNAL_NET any -> $HTTP_SERVERS $HTTP_PORTS (msg:"WEB-IIS CodeRed v2 root.exe access"; flow:to_server,established; uricontent:"/root.exe"; nocase; classtype:web-application-attack; reference:url,www.cert.org/advisories/CA-2001-19.html; sid:1256; rev:7;)

07/20-1
[
07/20-1

07/20-13:59:34.817953 64.165.187.170:4593 -> 193.54.194.111:80
[**] [1:1002:2] WEB-IIS cmd.exe access [**]
07/20-13:59:35.219711 64.165.187.170:4601 -> 193.54.194.111:80
[**] [1:1002:2] WEB-IIS cmd.exe access [**]
07/20-13:59:35.607048 64.165.187.170:4603 -> 193.54.194.111:80
[**] [1:1002:2] WEB-IIS cmd.exe access [**]
07/20-13:59:35.607048 64.165.187.170:4603 -> 193.54.194.111:80

SID	1002
Message	WEB-IIS cmd.exe access
Signature	alert tcp $EXTERNAL_NET any -> $HTTP_SERVERS $HTTP_PORTS (msg:"WEB-IIS cmd.exe access"; flow:to_server,established; content:"cmd.exe"; nocase; classtype:web-application-attack; sid:1002; rev:5;)

Exemple : alertes générées par Dragon

Too many details

[**] [1:1256:2] WEB-IIS CodeRed v2 root.exe access [**]
07/20-13:59:32.291193 64.165.187.170:4515 -> 193.54.194.111:80
[**] [1:1002:2] WEB-IIS cmd.exe access [**]
07/20-13:59:33.059882 64.165.187.170:4533 -> 193.54.194.111:80
[**] [1:1002:2] WEB-IIS cmd.exe access [**]
07/20-13:59:33.576217 64.165.187.170:4566 -> 193.54.194.111:80
[**] [1:1002:2] WEB-IIS cmd.exe access [**]
07/20-13:59:33.9[illegible]9027 64.165.187.170:4582 -> 193.54.194.111:80
[**] [1:
07/20-13:59
07/20-13:59
07/20-13:59

Nimda attack from 64.165.187.170 towards 193.54.194.111

[**] [1:1002:2] WEB-IIS cmd.exe access [**]
07/20-13:59:35.607048 64.165.187.170:4603 -> 193.54.194.111:80
[**] [1:1002:2] WEB-IIS cmd.exe access [**]
07/20-13:59:35.607048 64.165.187.170:4603 -> 193.54.194.111:80

Exemple : alertes générées par Dragon

Poor semantics

[**] [1:1256:2] WEB-IIS CodeRed v2 root.exe access [**]
07/20-13:59:32.291193 64.165.187.170:4515 -> 193.54.194.111:80
[**] [1:1002:2] WEB-IIS cmd.exe access [**]
07/20-13:59:33.059882 64.165.187.170:4533 -> 193.54.194.111:80
[**] [1:1002:2] WEB-IIS cmd.exe access [**]
07/20-13:59:33.576217 64.165.187.170:4566 -> 193.54.194.111:80
[**] [1:1002:2] WEB-IIS cmd.exe access [**]
07/20-13:59:33.9[illegible]9027 64.165.187.170:4582 -> 193.54.194.111:80
[**] [1:
07/20-13:59
07/20-13:59
07/20-13:59
07/20-13:59
[**] [1:1002:2] WEB-IIS cmd.exe access [**]
07/20-13:59:35.6[illegible]7048 64.165.187.170:4603 -> 193.54.194.111:80

Nimda attack from 64.165.187.170 towards 193.54.194.111, 193.54.194.111 not vulnerable

Alert correlation opportunities

- Correlation techniques
- Integration of system information
- Next step? : Grouping and alert fusion functions inside existing tools

Overall presentation (2/2)

- Case studies
  - Wireless networks
  - New generation avionics systems
  - Network appliances
  - Mobile telephony
  - Gaming devices
- Wrap-up (on-demand)
  - IDS
  - **Firewalls**
  - Anti-virus

Firewalls and Network protection

- Several design principles
  - (TCP,UDP) « state-based » firewalls
  - proxy firewalls
- Several security levels associated to DMZs
- Access control based on network flow characteristics
  - IP adresses : source, destination)
  - TCP/UDP : source port, destination port = protocol
  - action : drop, deny, allow, nat, trap, encrypt, ...

How do you define a rule, in practice?

- Given an application
  - vlc (what's this?)
  - http://mafreebox.freebox.fr/freeboxtv/playlist.m3u (starting to understand)
- which « does not work », « Port number? »
- First steps

```
ortalo@hurricane:~$ ping -c 1 mafreebox.freebox.fr
PING freeplayer.freebox.fr (212.27.38.253) 56(84) bytes of data.
64 bytes from freeplayer.freebox.fr (212.27.38.253): icmp_seq=1 ttl=64
   time=1.16 ms
--- freeplayer.freebox.fr ping statistics ---
1 packets transmitted, 1 received, 0% packet loss, time 0ms
rtt min/avg/max/mdev = 1.168/1.168/1.168/0.000 ms
ortalo@hurricane:~$ tethereal -i eth1 host 212.27.38.253
```

...nothing...

- Find (all) sources and destinations involved
  - IP_{eth1} and `212.27.38.253` (hmm...)
- Experimental approach : monitor drops one after the other while checking the network trafic

```
DROPPED IN= OUT=eth1 SRC=81.56.84.23 DST=212.27.38.253 LEN=52 TOS=0x00
  PREC=0x00 TTL=64 ID=48783 DF PROTO=TCP SPT=1047 DPT=80 SEQ=1610765695
  ACK=0 WINDOW=5840 RES=0x00 SYN URGP=0 OPT (020405B40101040201030300)
DROPPED IN= OUT=eth1 SRC=81.56.84.23 DST=212.27.38.253 LEN=52 TOS=0x00
  PREC=0x00 TTL=64 ID=48784 DF PROTO=TCP SPT=1047 DPT=80 SEQ=1610765695
  ACK=0 WINDOW=5840 RES=0x00 SYN URGP=0 OPT (020405B40101040201030300)
DROPPED IN= OUT=eth1 SRC=81.56.84.23 DST=212.27.38.253 LEN=52 TOS=0x00
  PREC=0x00 TTL=64 ID=1506 DF PROTO=TCP SPT=1048 DPT=80 SEQ=1611201085
  ACK=0 WINDOW=5840 RES=0x00 SYN URGP=0 OPT (020405B40101040201030300)
```

- Let's allow outbound HTTP

```
DROPPED IN= OUT=eth1 SRC=81.56.84.23 DST=212.27.38.253 LEN=52 TOS=0x00
   PREC=0x00 TTL=64 ID=22928 DF PROTO=TCP SPT=1082 DPT=554 SEQ=2534727009
   ACK=0 WINDOW=5840 RES=0x00 SYN URGP=0 OPT (020405B40101040201030300)
DROPPED IN= OUT=eth1 SRC=81.56.84.23 DST=212.27.38.253 LEN=52 TOS=0x00
   PREC=0x00 TTL=64 ID=22929 DF PROTO=TCP SPT=1082 DPT=554 SEQ=2534727009
   ACK=0 WINDOW=5840 RES=0x00 SYN URGP=0 OPT (020405B40101040201030300)
```

- and TCP/554 inbound (?)

```
DROPPED IN=eth1 OUT= MAC=00:50:bf:29:e7:88:00:07:cb:05:ec:fc:08:00
   SRC=212.27.38.253 DST=81.56.84.23 LEN=1356 TOS=0x00 PREC=0xE0 TTL=57
   ID=18727 DF PROTO=UDP SPT=32803 DPT=1044 LEN=1336
DROPPED IN=eth1 OUT= MAC=00:50:bf:29:e7:88:00:07:cb:05:ec:fc:08:00
   SRC=212.27.38.253 DST=81.56.84.23 LEN=1356 TOS=0x00 PREC=0xE0 TTL=57
   ID=18982 DF PROTO=UDP SPT=32803 DPT=1044 LEN=1336
```

- TV selection list available
- We allow UDP inbound (>1025)

```
hurricane:~# dmesg | grep 212
DROPPED IN= OUT=eth1 SRC=81.56.84.23 DST=212.27.38.253 LEN=80 TOS=0x00
   PREC=0x00 TTL=64 ID=6 DF PROTO=UDP SPT=1065 DPT=32769 LEN=60
DROPPED IN= OUT=eth1 SRC=81.56.84.23 DST=212.27.38.253 LEN=44 TOS=0x00
   PREC=0x00 TTL=64 ID=7 DF PROTO=UDP SPT=1065 DPT=32769 LEN=24
```

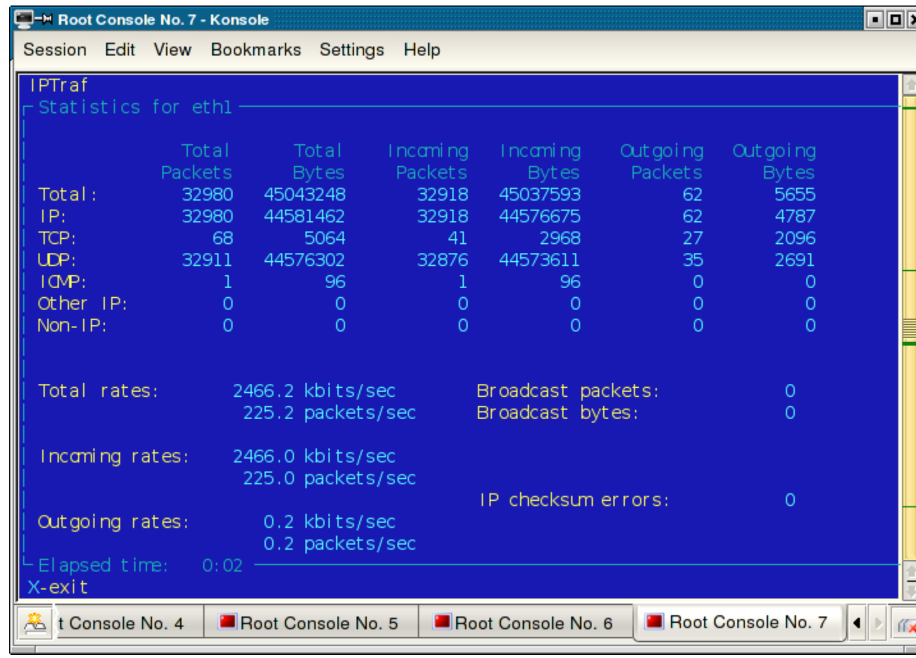
- The show begins...

- Channels keep on changing (?!?)

```
hurricane:~# dmesg | grep 212
DROPPED IN= OUT=eth1 SRC=81.56.84.23 DST=212.27.38.253 LEN=80 TOS=0x00
   PREC=0x00 TTL=64 ID=6 DF PROTO=UDP SPT=1065 DPT=32769 LEN=60
DROPPED IN= OUT=eth1 SRC=81.56.84.23 DST=212.27.38.253 LEN=44 TOS=0x00
   PREC=0x00 TTL=64 ID=7 DF PROTO=UDP SPT=1065 DPT=32769 LEN=24
```

- We allow outbound UDP on the port range 32000-33999
- « It works. »

```
hurricane:~# dmesg | grep 212
hurricane:~# iptraf
hurricane:~#
```



- By the way... where is the documentation?

One last note...

« The final step (…) simply adds a second Trojan horse to the one that already exists. The second pattern is aimed at the C compiler. The replacement code is a (…) self-reproducing program that inserts both Trojan horses in the compiler. (…) First we compile the modified source with the normal C compiler to produce a bugged binary. We install this binary as the official C. We can now remove the bugs from the source of the compiler and the new binary will reinsert the bugs whenever it is compiled. Of course, the login command will remain bugged with no trace in source anywhere. »

Morale

« *You can't trust code that you did not totally create yourself.*
(Especially code from companies that employ people like [him].) »

Ken Thomson, Reflections on Trusting Trust, *Turing award lecture*, in *Communications of the ACM*, vol.27, no.8, pp.761-763, August 1984.