PB173 - Tématický vývoj aplikací v C/C++ (podzim 2014)
Domain specific development in C/C++

Skupina: Aplikovaná kryptografie a bezpečné programování

https://is.muni.cz/auth/predmety/uplny_vypis.pl?fakulta=1433;obdobi=6184;predmet=788705

Petr Švenda svenda@fi.muni.cz

Konzultace: A406, Pondělí 15-15:50

CROCS
Centre for Research on Cryptography and Security

Some t me..

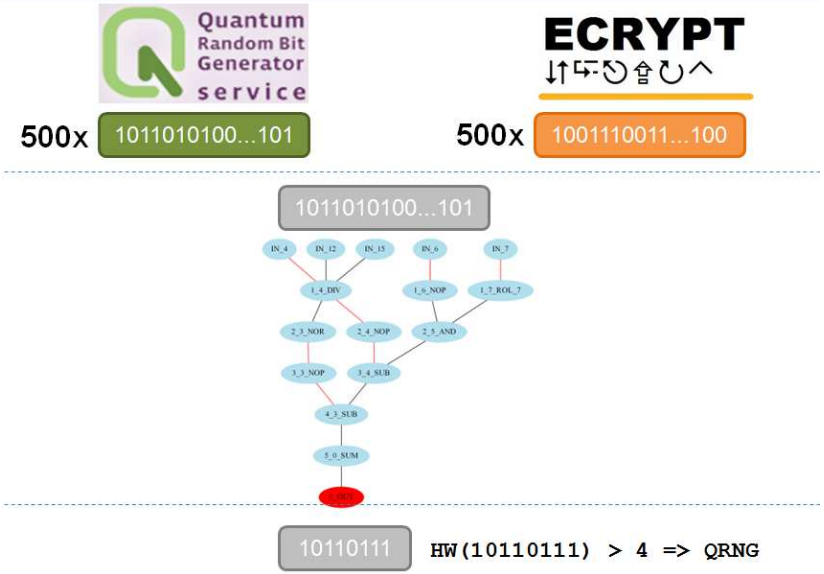
Genetic programming

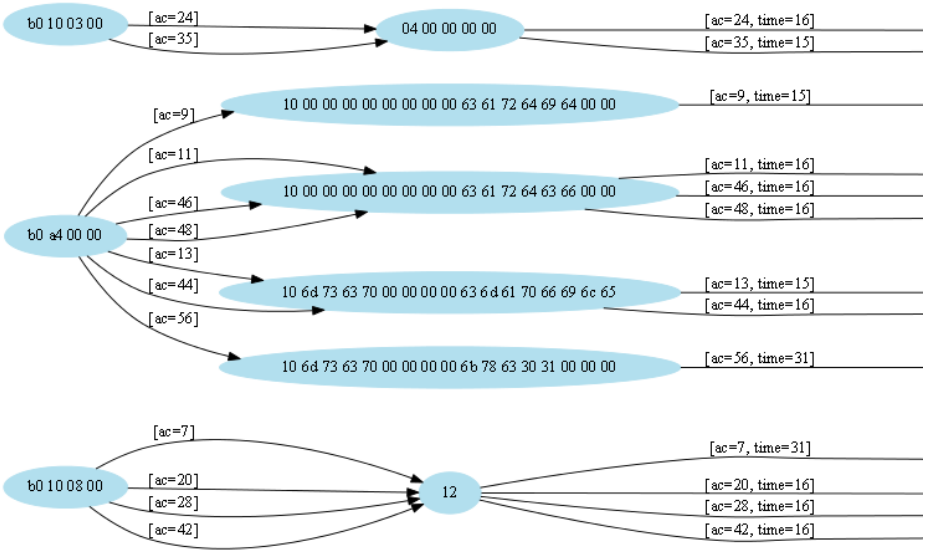
+

Distributed computing

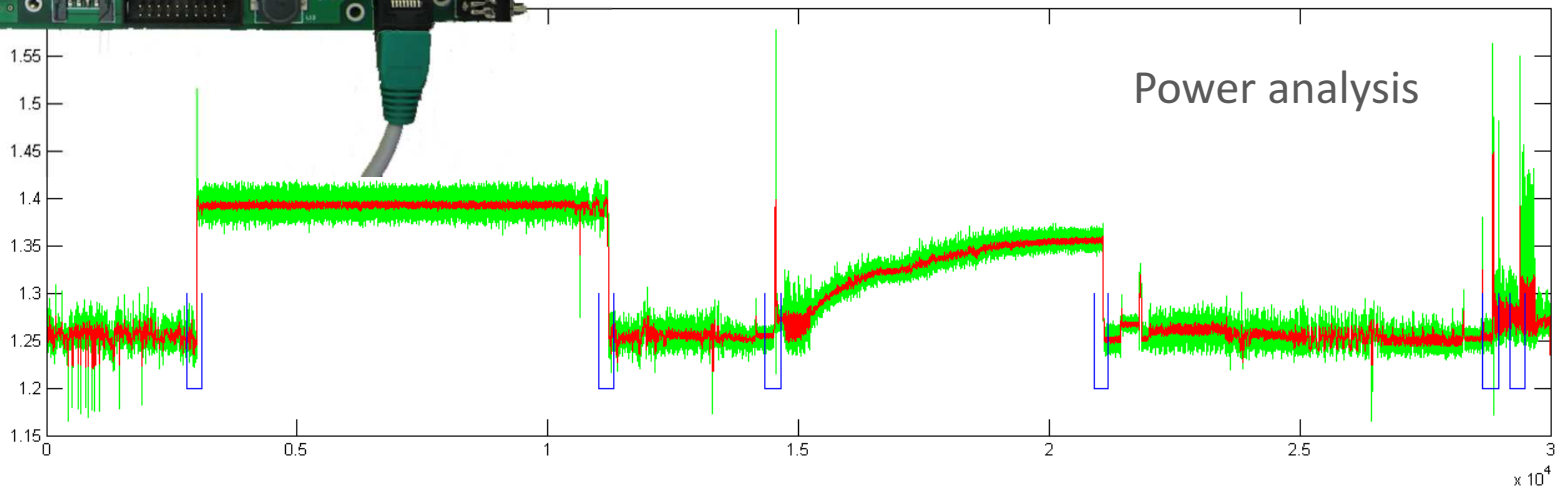
Secrecy amplification protocols for WSN

Random distinguisher for crypto fncs

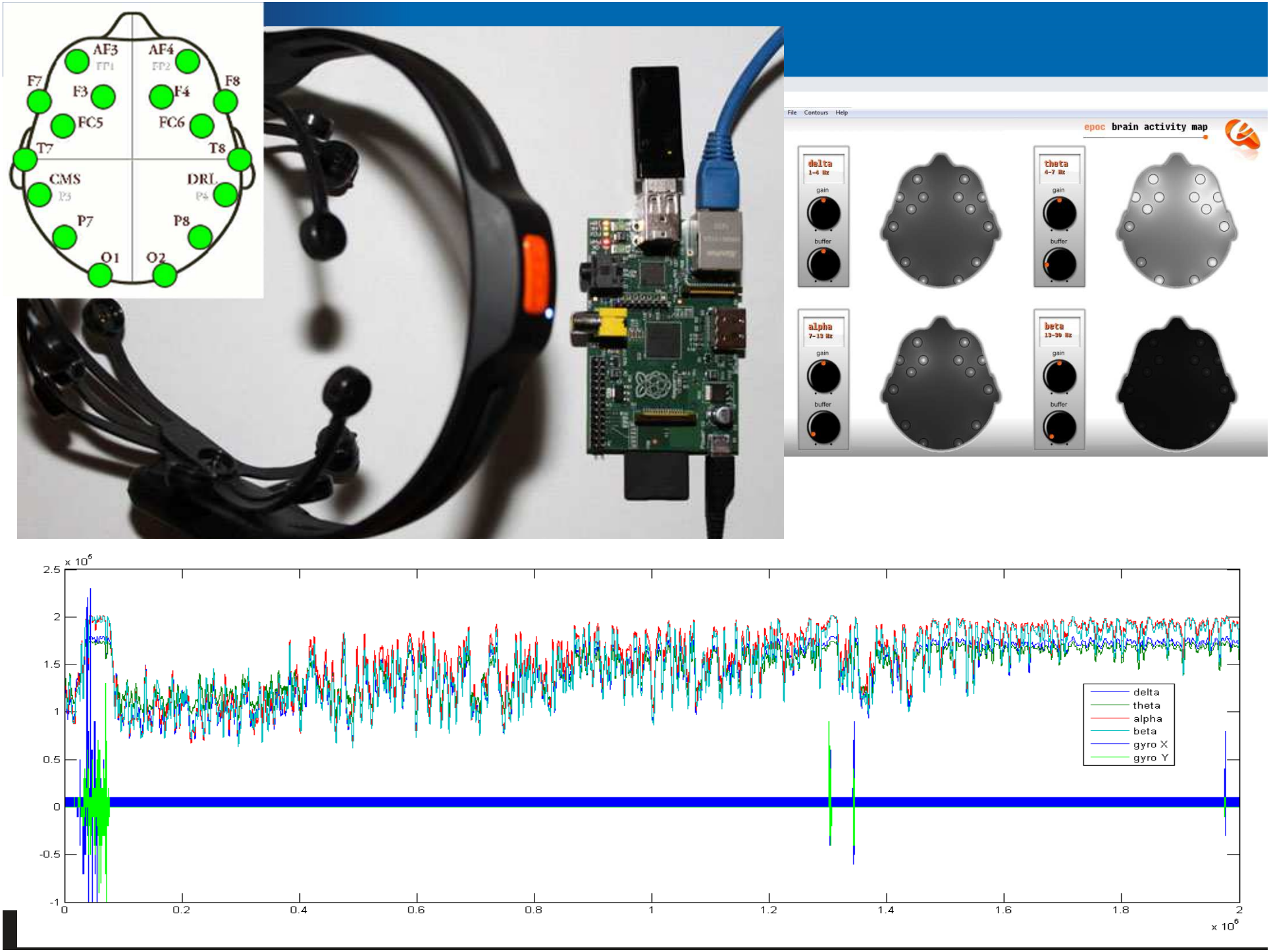




Security programming



Power analysis


AF3
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gyro X
gyro Y

http://astrolight.cz

M45 Pleiades star cluster and reflection nebula

Petr Švenda, http://www.
Equinox 80EDP 500m
Canon 400D IRmod @

NGC7000 in Cygnus

Saturn 30.6.2012

Petr Švenda, http://astrolight.cz
SW Orion 120/1000mm, stack 900 frames

The Sun 11.12.2011 (H-Alpha)

Petr Švenda, http://astrolight.cz, 11.12.2011
Solarscope Solarview 50mm 0,7Å, Canon 500D, 105 stack

ORGANIZAČNÍ INFORMACE

Co je cílem předmětu

- Získat zkušenosti s implementací většího programu
- Používat vývojové nástroje
- Naučit se dobré programátorské postupy
  - programování obecně
  - ale speciálně v oblasti bezpečnostních aplikací
- Získat praktické postřehy z implementací kryptografických aplikací
  - co nakonec ve firmě vyžadují

Co není cílem předmětu

- Detailní ovládnutí konkrétní technologie
  - zabrousíme do různých oblastí
- Pokročilé zvládnutí celého vývojového procesu
  - to jednoduše nestihneme
- Vysvětlovat základy kryptografie nebo srovnávat všechny možné varianty řešení problému
  - hlavně se budeme snažit prakticky programovat

Organizační

- Formality výuky
  - každotýdenní dvojhodinovka
  - evidovaná účast, 2 neúčasti bez omluvení OK
- Způsob výuky
  - max. cca 30 min./týdně úvod do problematiky
  - zbytek programování přímo na hodině
  - z mé strany průběžná konzultace nad vznikajícími problémy
  - default Windows (ale můžete pracovat i na jiné platformě)
- Samostatná práce
  - v týmech, průběžná tvorba většího projektu
  - dodělávání práce z hodiny
  - pravidelné bodované předvádění stavu projektu (každé cvičení)

Organizační (2)

- Používané nástroje
  - IDE, verzovací nástroje, Doxygen, debugger, analýza a kontrola kódu
  - konkrétní není striktně dané – použijte svoje oblíbené
  - default Visual Studio
- Hodnocení
  - účast
  - průběžná práce (10 bodů týdně)
  - prezentace celého projektu (30 bodů)
  - možné bonusy
  - max. 150 bodů, zisk alespoň 100 bodů na kolokvium

Rozdělení do týmů

- 2-3 osoby
- Společná práce, ale každý prezentuje svůj přínos
  - Iniciální prezentace domácího úkolu na dalším cvičení
  - zapracování připomínek, prezentace a hodnocení na dalším cvičení
- Využití sdíleného repozitáře (GitHub) + CI (Travis)
- Rozdělení provedeme až po 14 dnech
  - ustálení zapsaných studentů

Celkový přehled

- Základní podklady v ISu (interaktivní materiály)
  - PB173→Interaktivní osnovy → **Aplikovaná kryptografie a bezpečné programování (vyučující Petr Švenda)**
- Může se ale částečně měnit
  - uvidíme dle reálné obtížnosti, rychlosti postupu a zájmu
- Můžete otevřít vlastní řešený problém!

Twitter

- Twitter
  - https://twitter.com/rngsec
  - zveřejnění přípravy a slidů, občasné info
  - hash tag **#pb173_2014**
  - (opravdu důležité věci budou rozesílány hromadně na IS mail)
- Scribd
  - slidy zveřejňovány v IS materiálech i na Scribd.com
  - navíc možnost vkládání poznámek, připomínek, nejasností...

How good YOU are in English?

Apology all my mistakes, please.

Organization

- Seminars + assignments + project
- Assignments
  - Assigned regularly (nearly) every week
  - Initial assigments individual work
  - Most of assignments team work
  - expected workload: 4+ hours/week/participant
  - Network lab available to students
- Project: secure videoconferencing architecture

Attendance

- Seminars
  - Attendance obligatory
  - Absences must be excused at the department of study affairs
  - 2 absences are ok
- Assignments and projects
  - Partially done at seminar
  - Completed during students free time (e.g. at the dormitory)
  - Access to network lab and CRoCS lab is possible
  - Cooperation between team members necessary

Course resources

- Slides (PDF) available in IS
  - IS = Information System of the Masaryk University
- PB173→Interactive syllabi→ **Aplikovaná kryptografie a bezpečné programování (vyučující Petr Švenda)**
- Assignments (what to do) available in IS
  - Submissions done also via IS
- Additional tutorials/papers/materials from time to time will also be provided in IS
  - To better understand the issues discussed
- Recommended literatures

Plagiarism

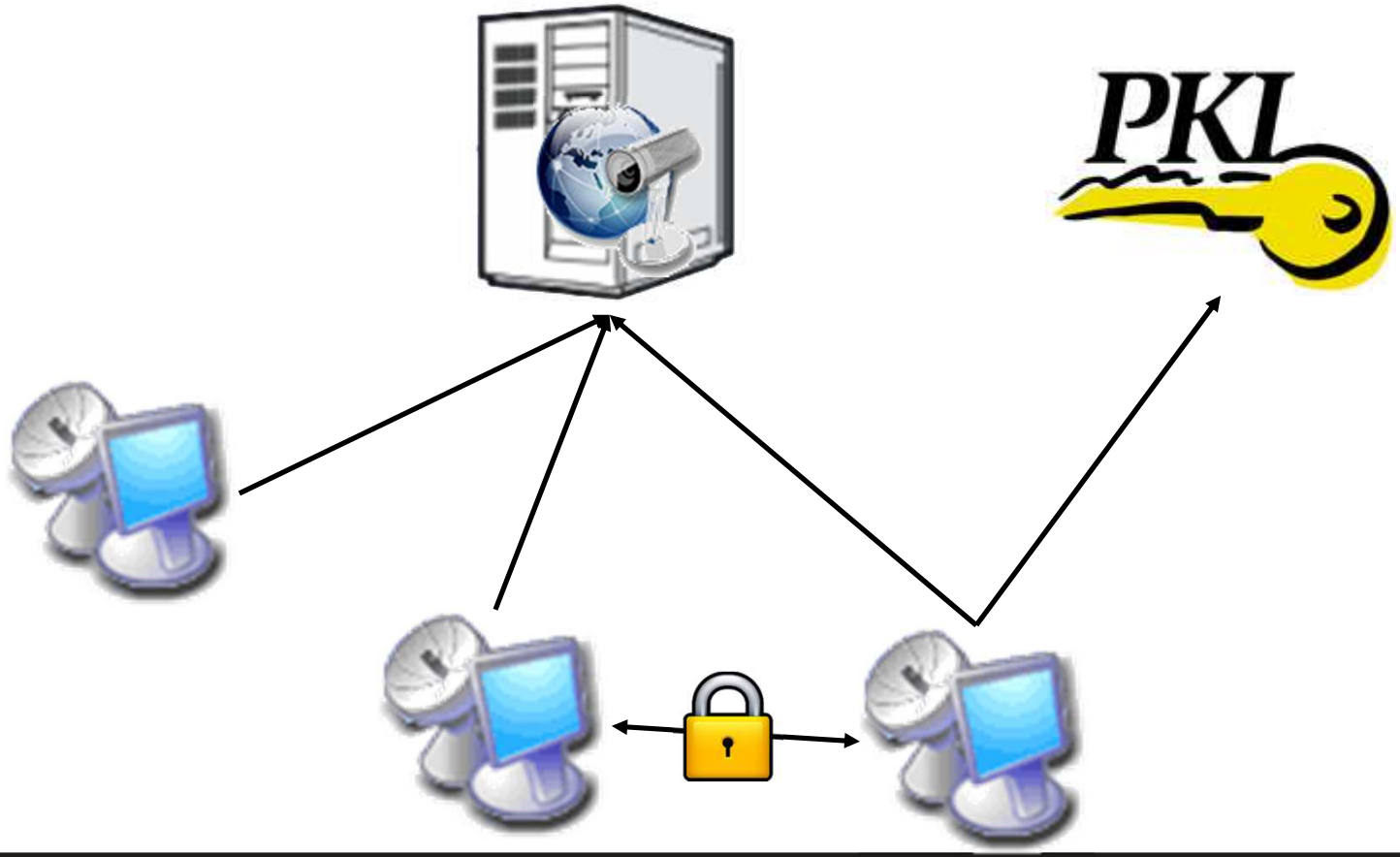
- Projects
  - Must be worked out by a team of 3 students
  - Every team member must show his/her contribution
- Plagiarism, cut&paste, etc. is not tolerated
  - Plagiarism is use of somebody else words/programs or ideas without proper citation
  - IS helps to recognize plagiarism
  - If plagiarism is detected student is assigned -5 points
  - In more serious cases the Disciplinary committee of the faculty will decide

Short questionnaire

- Do you know difference between symmetric and asymmetric cryptography?
- Do you known difference between block and stream cipher?
- Do you know DES and AES algorithm?
- Do you know ECB and CBC encryption mode?
- Do you know principle of hash functions?
- Do you know MD5 and SHA-1 algorithm?
- Do you known concept of digital signature?

"Theme" project

- Secure videoconferencing architecture



"Theme" project

- Certification authority
  - validates and issue user certificates
- Videoconferencing server
  - register and faciliate connection between users
- Client
  - provides operations related to end user usage

- Main focus on solving parts of the architecture

"Theme" project – some details

- Users obtains certificate of identity from Certification authority
- Users register with Videoconferencing server
- Videoconferencing server provides list of connected users, help to establish video connection and charge fee based on call length
- Client maintains user identity, related keys and provides high speed encryption of audio/video stream

Cryptographic libraries

Do not implement your own algorithms

- Time consuming (someone probably already did that before)
- Functional problems
- Low performance
- Security problems due to bugs
- Security problems due to missing defense against implementation attacks

Use well-known implementations

- Use well-known libraries
  - OpenSSL, PolarSSL, GnuPG, BouncyCastle (Java)
- Or implementation of algorithms from well-established authors
  - Brian Gladman, Eric A. Young …

Complexity matters

- Complexity of library implementation should match your needs
  - usually, you need only one or two algorithms
- Multiprocessor or CPU-independent implementation can be overkill
  - and just increase risk of error
- Do you really need library with object-oriented design?

Complexity matters (2)

- Large libraries are not always the most suitable ones
- OpenSSL is complex and interconnected
  - e.g., AES is extractable much easier from PolarSSL then from OpenSSL

Code authenticity

- Source code signature
  - Do you really have original source codes?
  - MD5/SHA1 hash (where to get “correct” hash value?)
  - GPG/PGP
- Generate your own GPG/PGP signature keys
  - use them for inter-team communication
  - sign your code releases

Resilience against bugs

- Do not design algorithms/protocols by yourself
- Try to find existing standards
  - NIST, RSA PKCS, RFC, ISO/ANSI
- Try not to deviate from standards
  - compatibility and compliance
  - no need for (time consuming) specification of detailed your scheme
  - small change can have big security impacts

Libraries used often - OpenSSL

- Pros:
  - Very rich library
    - lots of algorithms, protocols, paddings
    - not “just” SSL
  - well tested functionally & security over time!
  - significant amount of existing examples on web
- Cons:
  - API is complex and sometimes harder to understand
  - (started as Eric Young’s personal attempt to learn BigInts ☺)
  - relatively low-level functions (can be pros!)
  - code is significantly interconnected
    - not suitable for extraction of single algorithm
  - poor official documentation

OpenSSL - problems

- Heart bleed
- Apple goto bug

Webová služba: opakovač paketů

```
network_receive(in_packet, &in_packet_len); // TLV packet
in = in_packet + 3;
```

unsigned char* in


```
out_packet = malloc(1 + 2 + length);
out = out_packet + 3;

memcpy(out, in, length);
```

unsigned char* out


```
network_transmit(out_packet);
```

Problém?

```
network_receive(in_packet, &in_packet_len); // TLV packet
in = in_packet + 3;
```

unsigned char* in


```
out_packet = malloc(1 + 2 + length);
out = out_packet + 3;

memcpy(out, in, length);
```

in_packet_len != length + 3

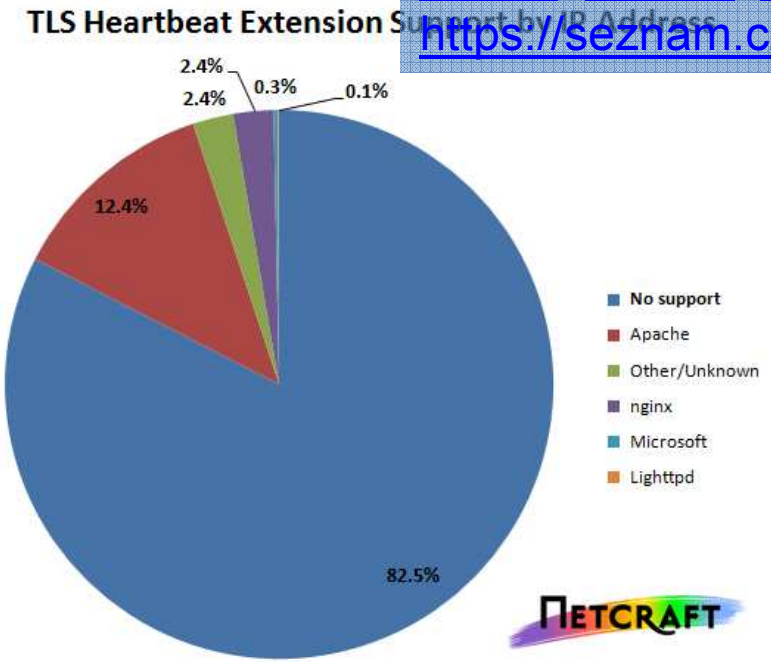
unsigned char* out


```
network_transmit(out_packet);
```

Problém!

O jak závažnou chybu se jedná?

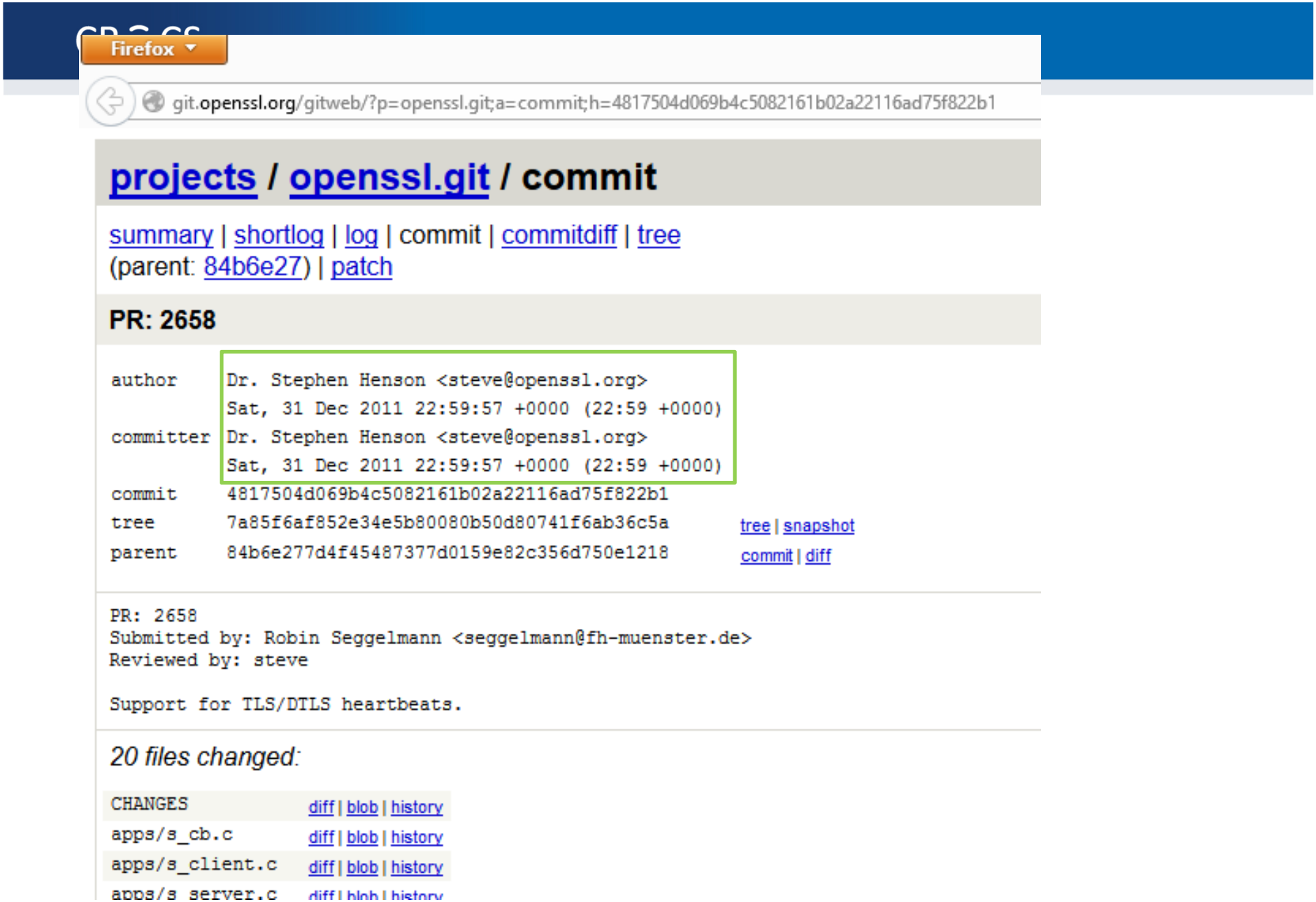
17% SSL web serverů (OpenSSL 1.0.1)
Twitter, GitHub, Yahoo, Tumblr, Steam, DropBox, DuckDuckGo…
https://seznam.cz, https://fi.muni.cz …



- http://news.netcraft.com/archives/2014/04/08/half-a-million-widely-trusted-websites-vulnerable-to-heartbleed-bug.html

Ponaučení

- Vždy VELMI rigidně kontrolujte vstupní argumenty
- Nebezpečný není jen zápis za konec pole, ale i čtení
- Nedůvěřujte informacím od klienta
  - Ani když jste vy sami jeho tvůrci (změna na síťové vrstvě)
- Pro síťové aplikace preferujte jiné jazyky než C
  - Např. automatická kontrola mezí polí (Java, C#)
  - Nenahrazuje kontrolu argumentů!
- Open-source sám o sobě nezajišťuje kód bez chyb
  - "given enough eyeballs, all bugs are shallow" L. Torvalds
- (Nedělejte commity ve spěchu před oslavou)

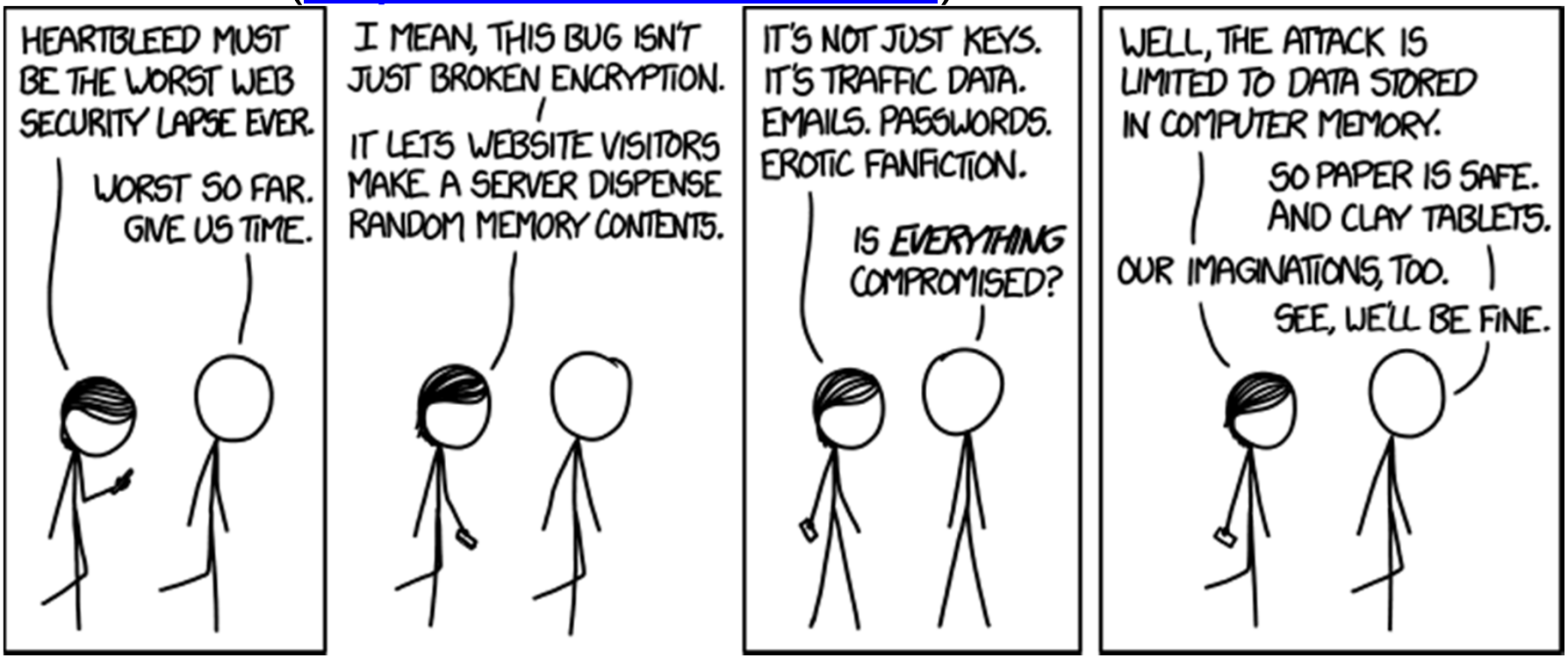

Firefox
git.openssl.org/gitweb/?p=openssl.git;a=commit;h=4817504d069b4c5082161b02a22116ad75f822b1
projects / openssl.git / commit
summary | shortlog | log | commit | commitdiff | tree
(parent: 84b6e27) | patch
PR: 2658
author Dr. Stephen Henson <steve@openssl.org>
Sat, 31 Dec 2011 22:59:57 +0000 (22:59 +0000)
committer Dr. Stephen Henson <steve@openssl.org>
Sat, 31 Dec 2011 22:59:57 +0000 (22:59 +0000)
commit 4817504d069b4c5082161b02a22116ad75f822b1
tree 7a85f6af852e34e5b80080b50d80741f6ab36c5a
tree | snapshot
parent 84b6e277d4f45487377d0159e82c356d750e1218
commit | diff
PR: 2658
Submitted by: Robin Seggelmann <seggelmann@fh-muenster.de>
Reviewed by: steve
Support for TLS/DTLS heartbeats.
20 files changed:
CHANGES diff | blob | history
apps/s_cb.c diff | blob | history
apps/s_client.c diff | blob | history
apps/s_server.c diff | blob | history

Reference

- Všeobecné informace
  - http://heartbleed.com/
- Testování zranitelnosti konkrétní stránky
  - https://filippo.io/Heartbleed/
- Analýza problému na úrovni zdrojáku
  - http://nakedsecurity.sophos.com/2014/04/08/anatomy-of-a-data-leak-bug-openssl-heartbleed
  - http://blog.existentialize.com/diagnosis-of-the-openssl-heartbleed-bug.html

O jak závažnou chybu se jedná? ☺

- XKDC (https://xkcd.com/1353/)



Libraries used often - PolarSSL

- Pros:
  - API is simple and clear
  - easy to extract single algorithm
- Cons:
  - fewer supported algorithms and standards
  - dual licensing, but not BSD-like license

How to use library

- Extract code and compile alone
  - some work with extraction
  - small, clean and self-containing result
- Compile against whole library
  - usually easy to do
  - but dependence on possibly unused code
- Link statically against dynamic library
  - dll must be always present to run program

How to use library (2)

- Link dynamically against dynamic library
  - try to open dll file and obtain function handle
- Link against service provider functions
  - Cryptography Service Providers in particular
  - API for listing of available service providers (CryptEnumProviders)
  - standardized functions provided by providers http://msdn.microsoft.com/en-us/library/aa380252%28v=VS.85%29.aspx#service_provider_functions

Security implications of dynamic libraries

- Library can be forged and exchanged
- Library-in-the-middle attack easy
  - data flow logging
  - input/output manipulation
- Library outputs can be less checked then user inputs
  - feeling that library is my “internal” stuff and should play by „my“ rules
- Library function call can be behind logical access controls

Practical assignment

Practical assignment

- Download OpenSSL and PolarSSL library
  - and check signature (gpg --verify)
- Write small project (PolarSSL based)
  - read, encrypt and hash supplied file, write into out file
  - read, verify hash and decrypt file
  - use AES-128 in CBC mode and SHA2-512
  - use PKCS#7 padding method for encryption (RFC 3852)
- Start with New Project+PolarSSL+AES

Questions ?

Submissions, deadlines

- Upload application source codes as single zip file into IS Homework vault (Crypto - 1. homework (AES+SHA2))
- DEADLINE: 22.9. 23:59 (first part)
  - application capable to read, encrypt, decrypt, hash
  - Text file containing description how you did PGP signature verification (whole process including import of public keys etc.)
  - selected solutions will be discussed during next lecture (23.9.)
  - 0-5 points assigned
- DEADLINE 29.9. 23:59 (second part)
  - finalization of codes based on the discussions during lecture
  - addition of unit tests
  - 0-5 points assigned