PB173 - Tématický vývoj aplikací v C/C++ Domain specific development in C/C++

Skupina: Aplikovaná kryptografie a bezpečné programování
https://is.muni.cz/auth/predmety/uplny_vypis?fakulta=1433;obdobi=6384;predmet=871304

Petr Švenda svenda@fi.muni.cz
Konzultace: A406, Pondělí 15-15:40

Centre for Research on Cryptography and Security

Some t me..

Genetic programming

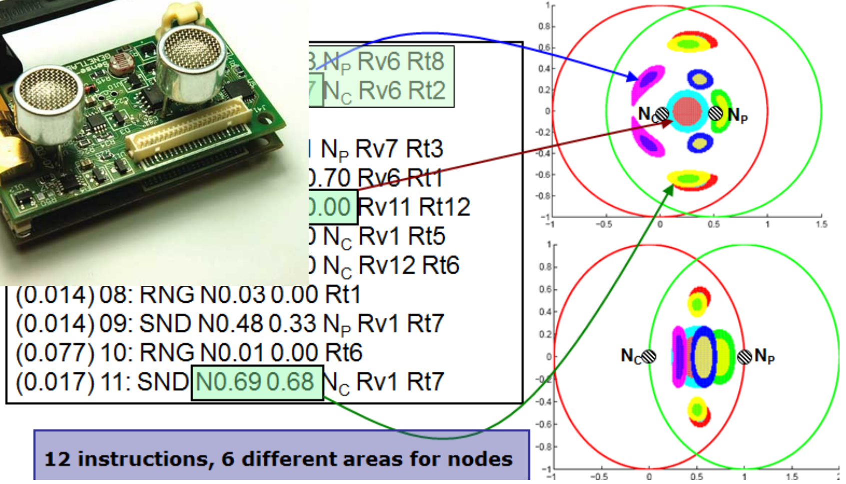
+

BOINC

Distributed computing

⇓

Secrecy amplification protocols for WSN



```
3 NP Rv6 Rt8
7 NC Rv6 Rt2
I NP Rv7 Rt3
).70 Rv6 Rt1
).00 Rv11 Rt12
) NC Rv1 Rt5
) NC Rv12 Rt6
(0.014) 08: RNG N0.03 0.00 Rt1
(0.014) 09: SND N0.48 0.33 NP Rv1 Rt7
(0.077) 10: RNG N0.01 0.00 Rt6
(0.017) 11: SND N0.69 0.68 NC Rv1 Rt7
```

12 instructions, 6 different areas for nodes

Random distinguisher for crypto fncs

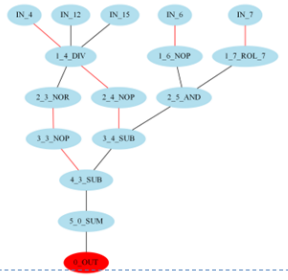
Quantum Random Bit Generator service

ECRYPT

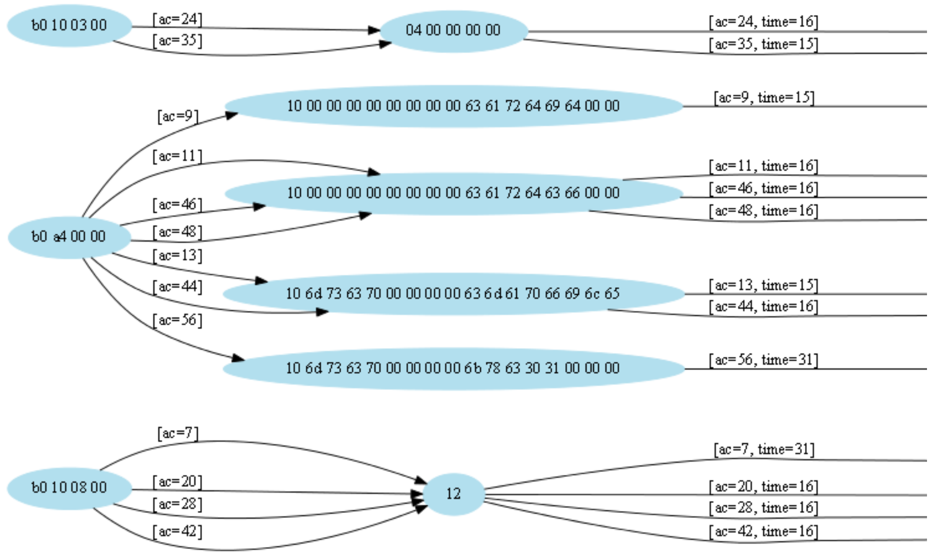
500x 1011010100...101

500x 1001110011...100

1011010100...101

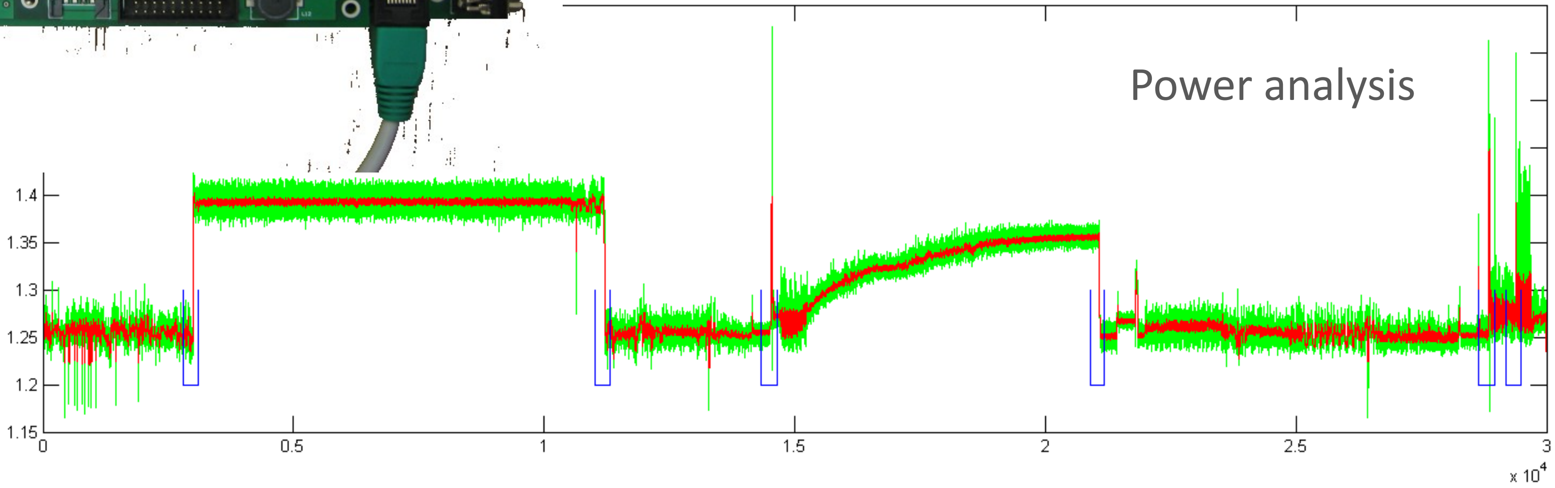


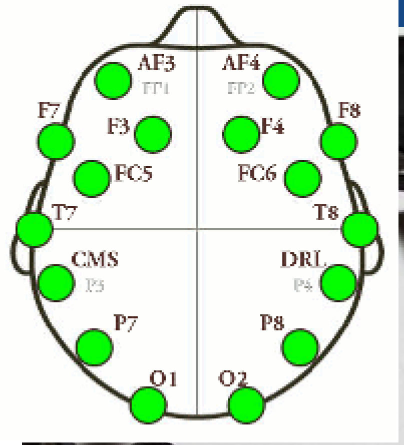
10110111 HW(10110111) > 4 => QRNG

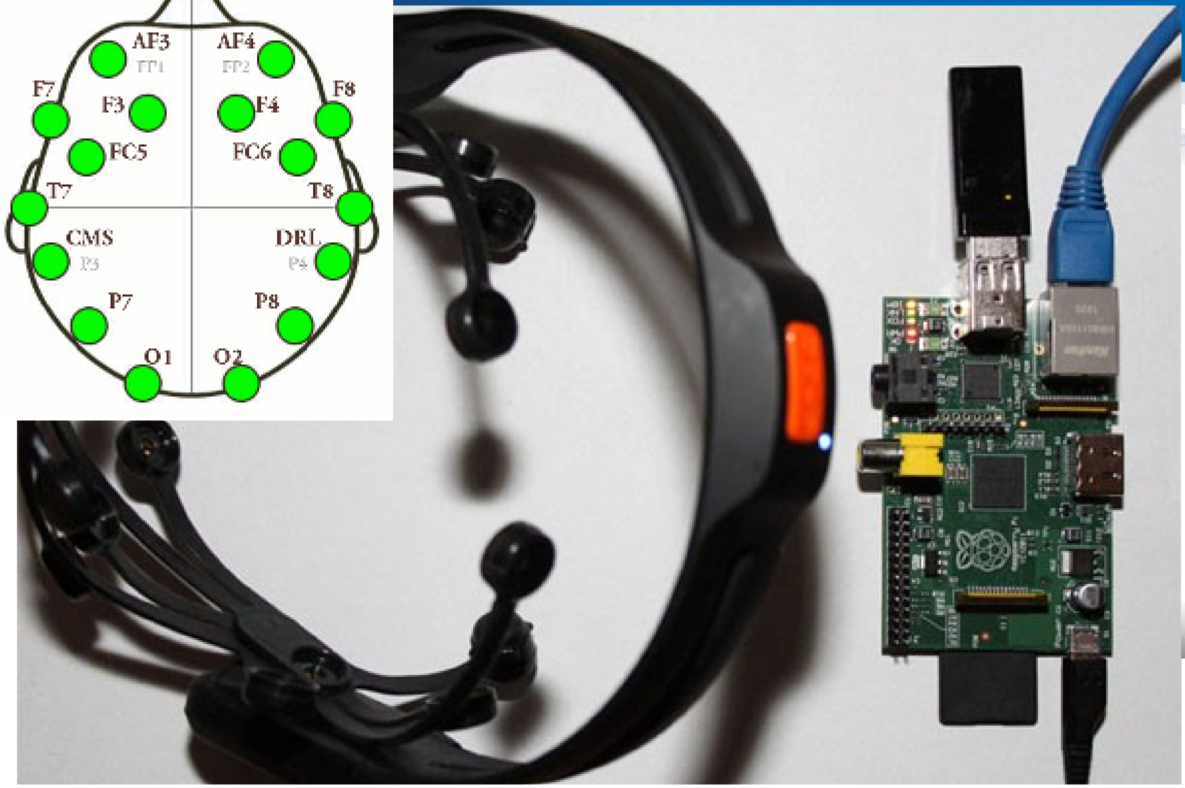


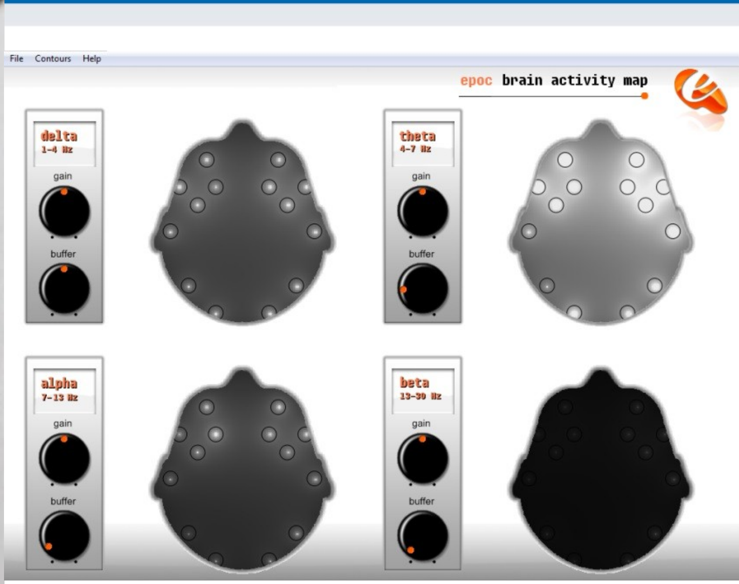
Security programming

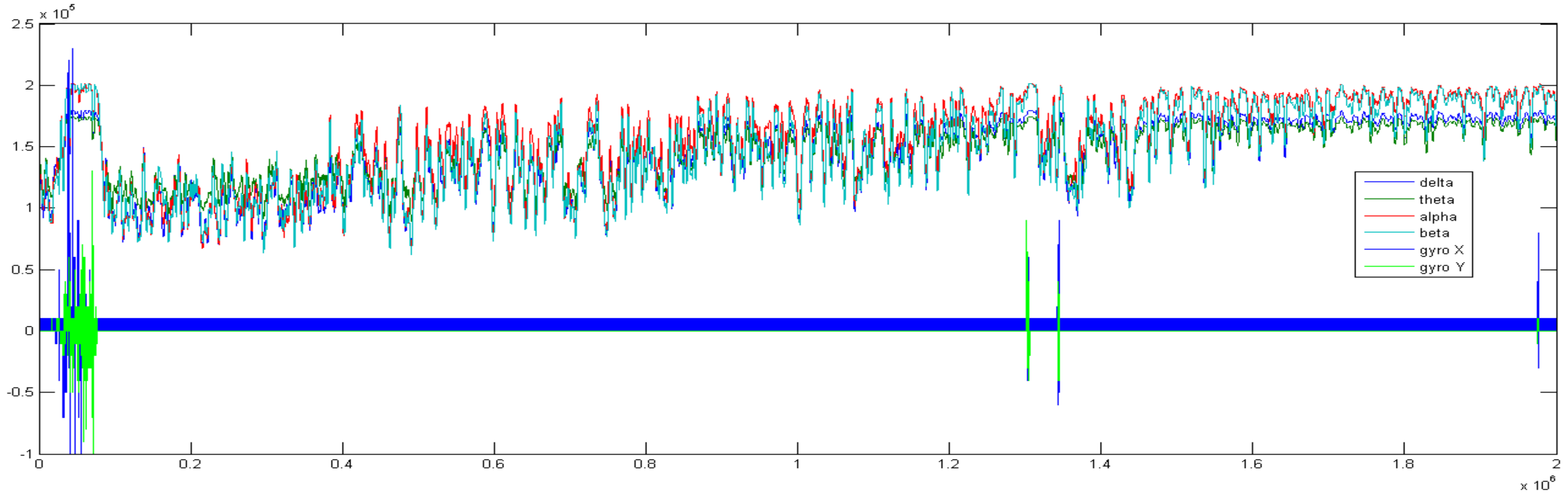
Power analysis




AF3
AF4
FP1
FP2
F7
F8
F3
F4
FC5
FC6
T7
T8
CMS
DRL
P3
P4
P7
P8
O1
O2



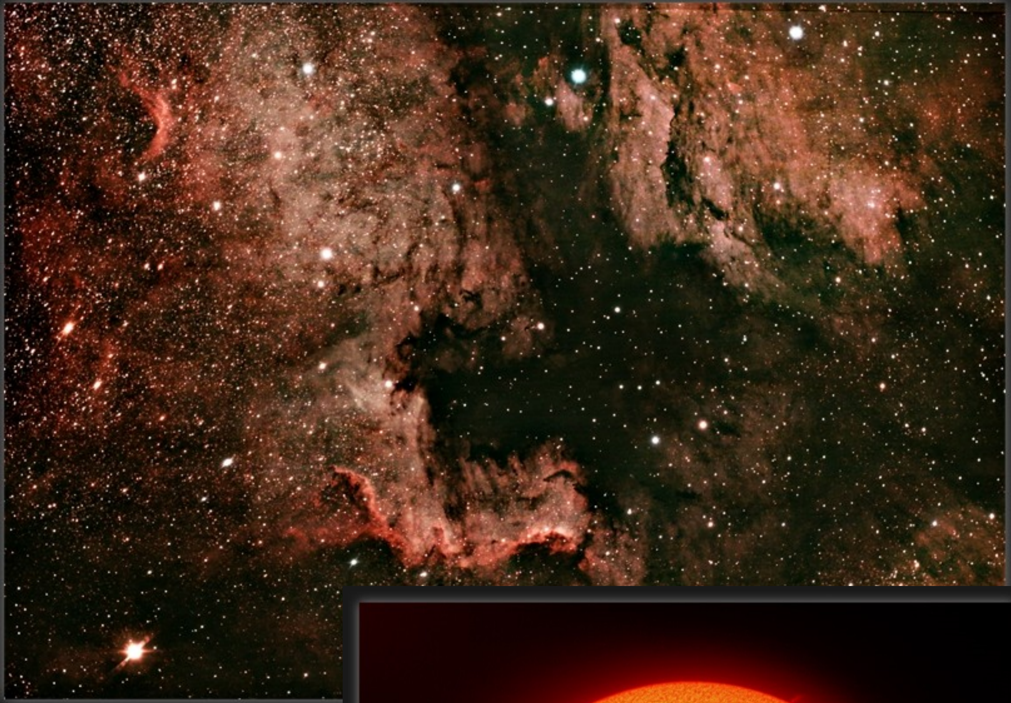

File
Contours
Help
epoc brain activity map
delta
1-4 Hz
gain
buffer
theta
4-7 Hz
gain
buffer
alpha
7-13 Hz
gain
buffer
beta
13-30 Hz
gain
buffer

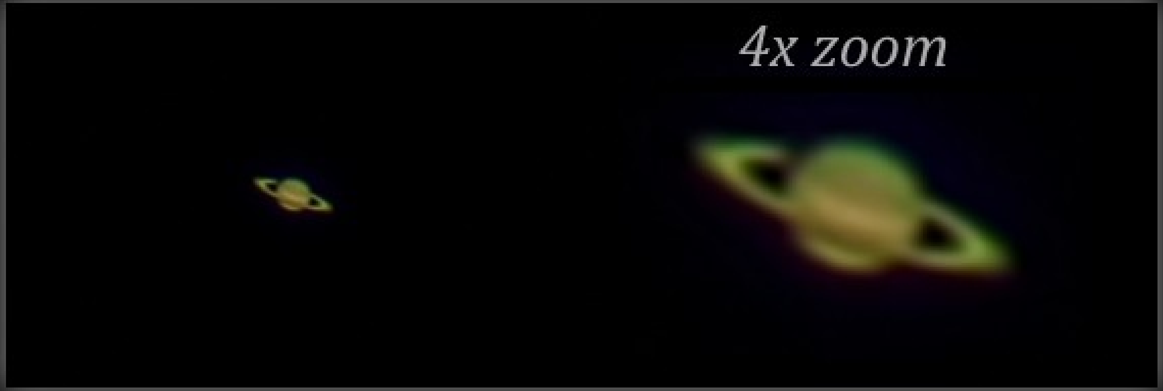

x 10^5
2.5
2
1.5
1
0.5
0
-0.5
-1
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
x 10^6
delta
theta
alpha
beta
gyro X
gyro Y

http://astrolight.cz

M45 Pleiades star cluster and reflection nebula

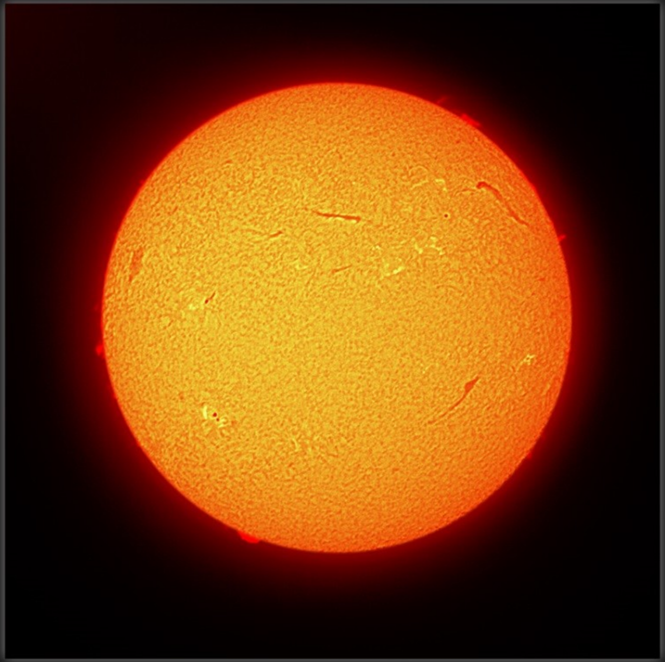
Petr Švenda, http://www.
Equinox 80EDP 500m
Canon 400D IRmod @


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
  - cca 30 min./týdně úvod do problematiky
  - zbytek vaše 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 (git), Doxygen, debugger, analýza a kontrola kódu (CppCheck, Coverity)
  - GitHub + TravisCI + Coverity
  - Ne vše je striktně dané – ptejte se a použijte svoje oblíbené
- 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
  - Po ustálení zapsaných studentů

How good YOU are in English?

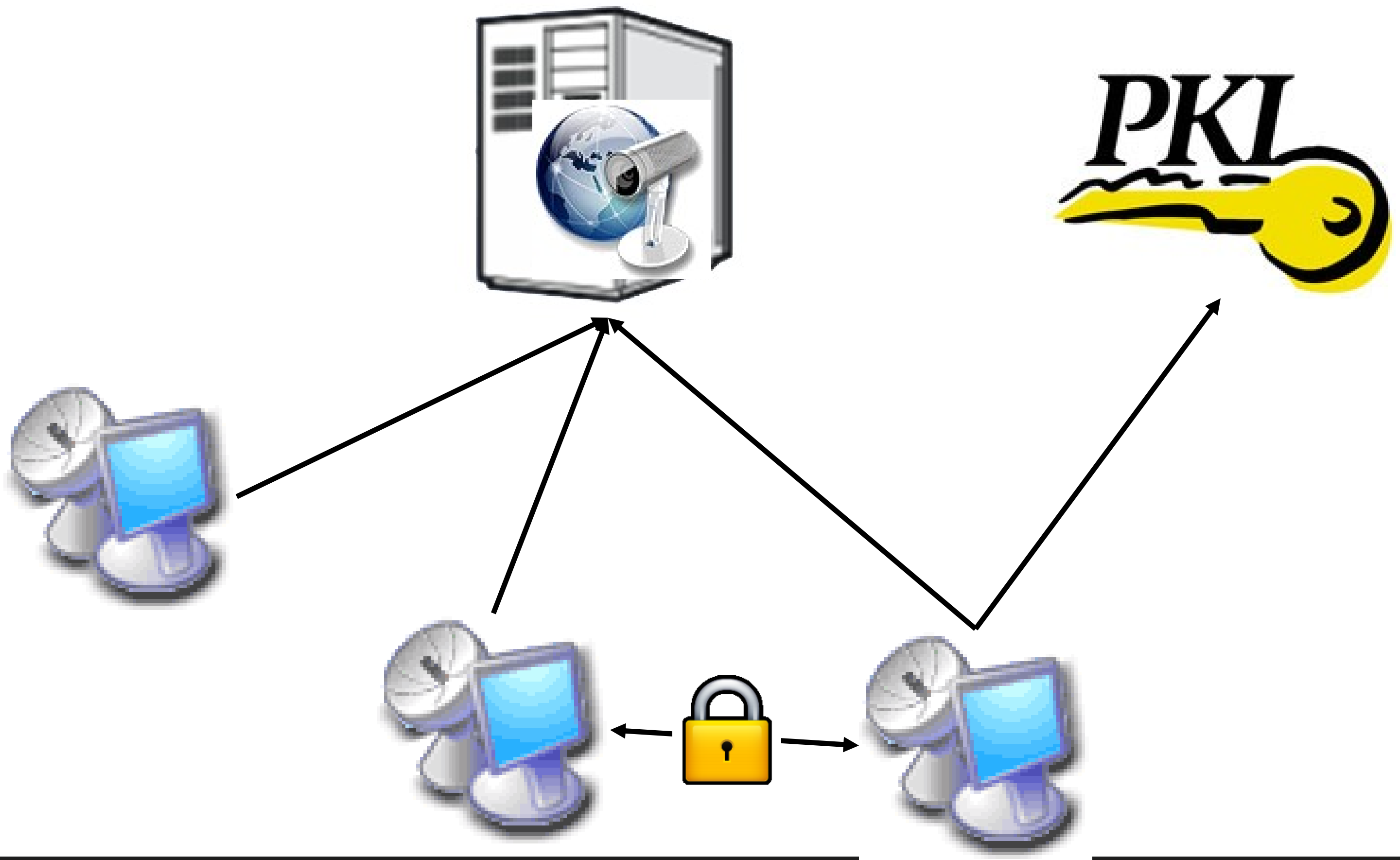
Apology for all my mistakes, please.

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, SHA-1/2/3 algorithm?
- Do you known concept of digital signature?
- Do you know what perfect forward secrecy means?

"Theme" project – Secure IM

- Secure instant messaging and data sharing



"Theme" project – Secure IM

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

- Expected at the end: working networking application with security features

Cryptographic libraries

Cryptographic libraries - overview

1. Why not to implement own crypto algorithm/protocol
2. Adequate complexity of library
3. How to get authentic source code
4. Common libraries: OpenSSL, mbed TLS
5. How to use library

Do NOT implement your own algorithms

- Time consuming (probably already done before)
- Functional problems
- Low performance
- Security problems due to bugs
- Security problems due to missing defence against implementation attacks

Do NOT implement your own protocols

- 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

Use well-known implementations

- Use well-known libraries
  - OpenSSL, PolarSSL, GnuPG, BouncyCastle (Java)
- Or implementation of algorithms from well-established authors (for uncommon alg)
  - 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?
- Large libraries are not always the most suitable ones
  - OpenSSL is complex and interconnected
  - e.g., AES is extractable much easier from mbedTLS (PolarSSL) than from OpenSSL

Code authenticity

- Source code signature
  - Do you really have original binary/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 (on GitHub)

Which one you like more? Why?

ARM mbed TLS

```
/**
 * \brief         Output = HMAC-SHA-512( hmac key, input buffer )
 *
 * \param key      HMAC secret key
 * \param keylen   length of the HMAC key
 * \param input    buffer holding the  data
 * \param ilen     length of the input data
 * \param output   HMAC-SHA-384/512 result
 * \param is384    0 = use SHA512, 1 = use SHA384
 */
void sha512_hmac( const unsigned char *key, size_t keylen,
                  const unsigned char *input, size_t ilen,
                  unsigned char output[64], int is384 );
```

OPENSSL

```
unsigned char *HMAC(const EVP_MD *evp_md, const void *key, int key_len,
                    const unsigned char *d, size_t n, unsigned char *md,
                    unsigned int *md_len);
```

Common libraries – 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

Common libraries – mbed TLS

- (Formely PolarSSL)
- Pros:
  - API is simple and clear
  - Easy to extract single algorithm
  - Now widely used, reasonably tested
- Cons:
  - fewer supported algorithms and standards
  - dual licensing, but not BSD-like license

How to use library

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

How to use library (2)

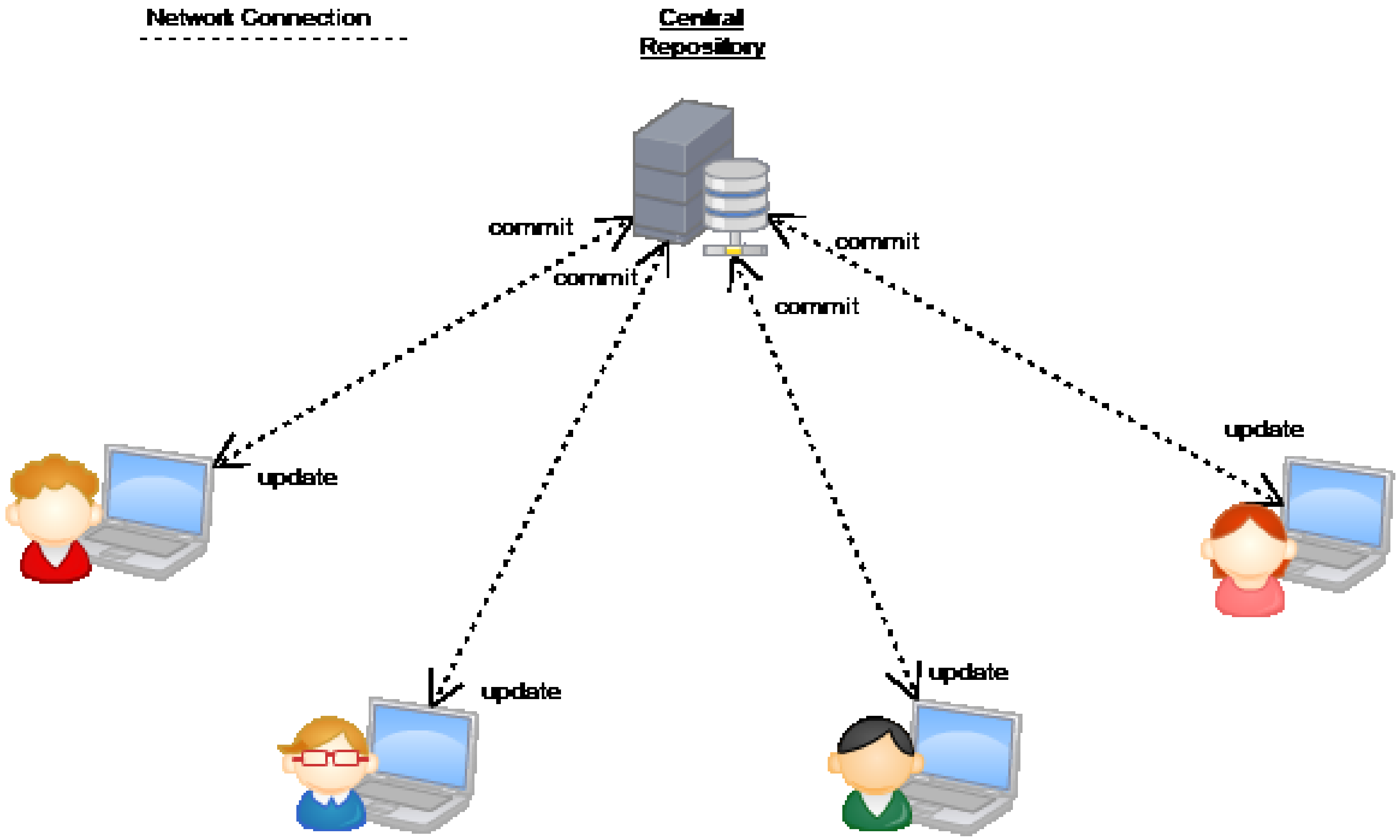
4. Link dynamically against dynamic library
   - try to open dll file and obtain function handle
5. Link against service provider functions
   - Cryptography Service Providers in particular
   - API for listing of available service providers (CryptEnumProviders)
   - standardized functions provided by 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 than user inputs
  - feeling that library is my “internal” stuff and should play by „my“ rules
- Library function call can be behind logical access controls
- Library can contain bugs
  - Serious development also needs 3rd party libraries control process

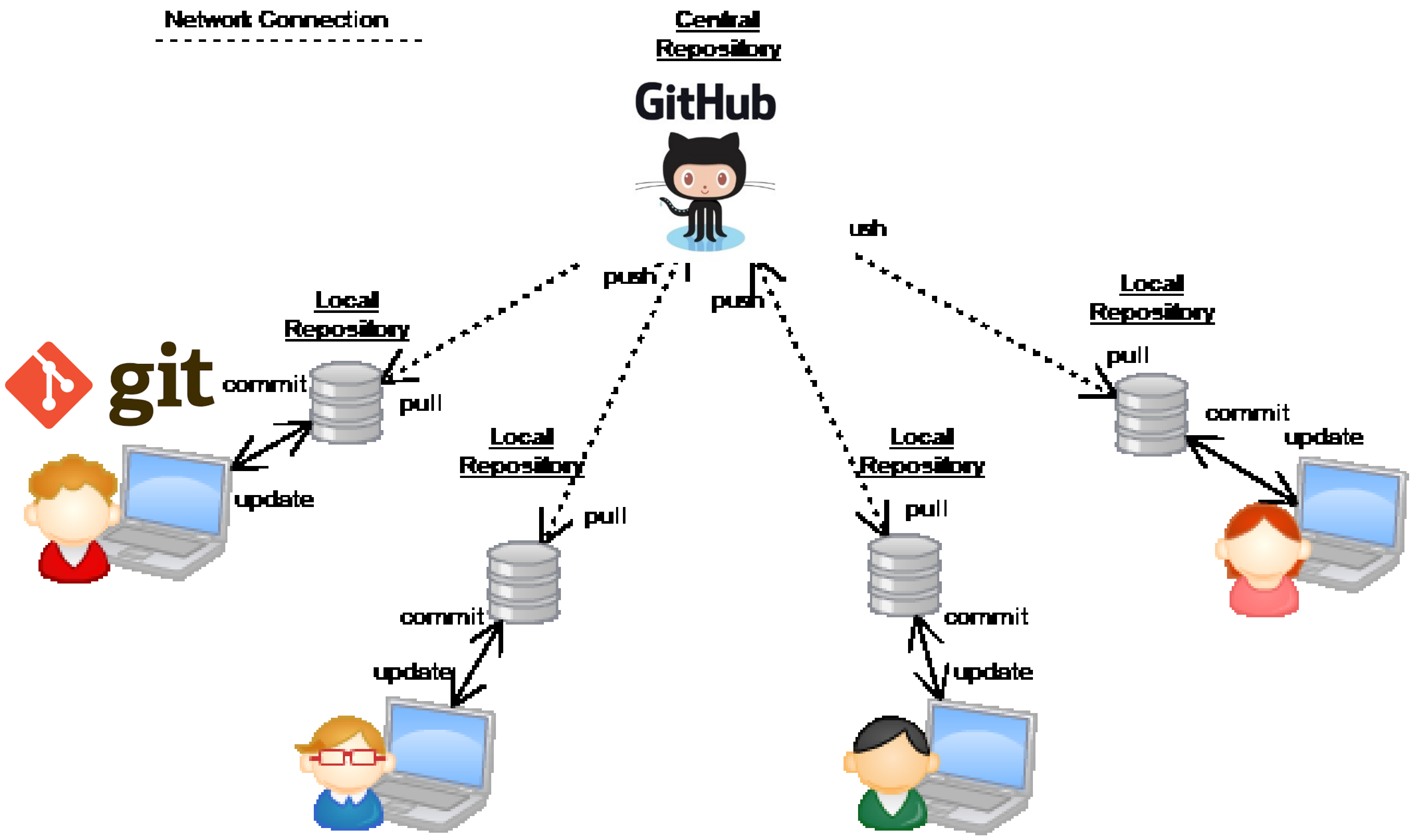
Practical assignment

SVN style – central repository



ps://programmers.stackexchange.com/questions/35074/im-a-subversion-geek-why-should-i-consider-or-not-consider-mercurial-or-git-or

GIT-style – distributed repository



ps://programmers.stackexchange.com/questions/35074/im-a-subversion-geek-why-should-i-consider-or-not-consider-mercurial-or-git-or

Setup your GitHub repository

1. Setup your GitHub account and repository
   - E.g., PB173 test
   - .gitignore C++
   - License MIT
2. Create first milestone (Issues→Set milestone→Create…)
3. Create first issue (Labels, Milestone, Assignee)
   - “Setup initial repo files”
4. Install git locally (GitHub client, TortoiseGit…)
5. Git Clone (your repository)
   - Into local directory

Use your GitHub repository

- Create small project (your favourite IDE)
  - Commit, Push
- Try to modify some files locally
  - Commit, Push
- Try to modify some files in repo via web interface
  - Simulated parallel modification by other developer
  - Git Pull / Sync
- Close your first issue ☺

Practical assignment

- Download *mbed TLS* (formerly PolarSSL) library
  - and check signature (gpg --verify)
- Write small project (mbed TLS 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+mbedTLS+AES

Questions

Submissions, deadlines

- Commit into your GitHub repository (frequently ☺)
- Upload application source codes as single zip file into IS
  - Use GitHub's download ZIP feature
  - Homework vault (Crypto - 1. homework (AES+SHA2))
- DEADLINE: 29.2. 12:00 (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.)
  - 0-5 points assigned
- DEADLINE 7.3. 12:00 (second part)
  - addition of unit tests
  - 0-5 points assigned