PB173 - Tématický vývoj aplikací v C/C++ (Podzim/Fall 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

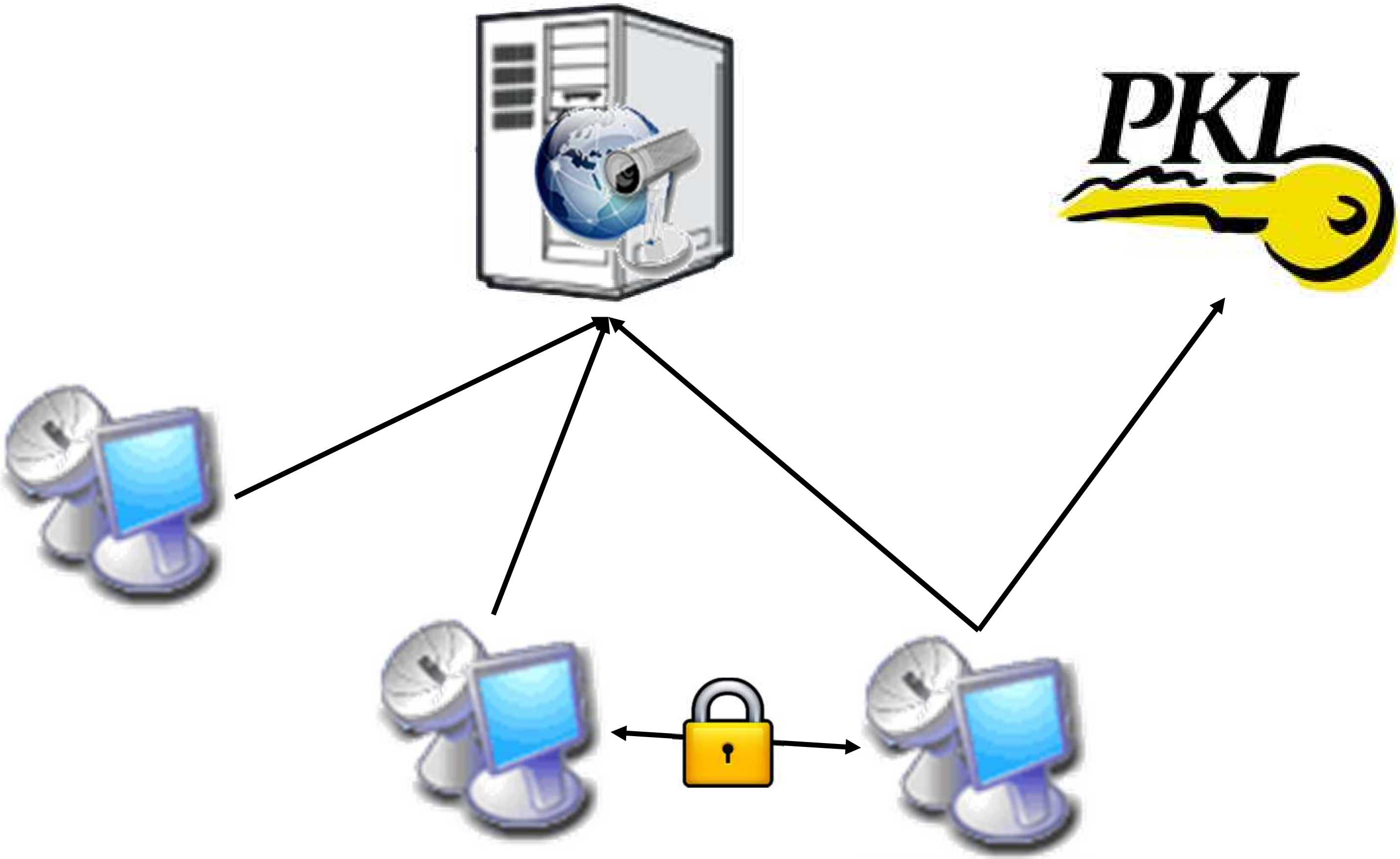
CRoCS
Centre for Research on Cryptography and Security

Teams

- 2-3 persons
- Joint work, but every one presents its contribution
  - Presentation on next seminar
- Form the teams now!
  - TODO teams

"Theme" project

- Secure videoconferencing 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

Practical assignment

- Design and document API to:
  1. **new user registration**
  2. **user authentication to server**
  3. **obtain list of other users**
  4. **establish secure channel to other (online) users (ENC, MAC)**
  5. **exchange stream data with other user (audio only)**
  6. **close secure channel**
  7. **disconnect user from server**
  8. **...?**
- Document functions in JavaDoc-style (Doxygen)
- CA/Client/Server are separate processes
  - design communication over sockets or http requests

Practical assignment – cont.

- Prepare document and presentation with design decisions
  - 2-3xA4 document (overview, functions, crypto used...)
  - 4-5 slides (presentation)
- Your design will be presented and discussed next week

Designing good API, authenticated encryption

Principles of good API

1. Be minimal
2. Be complete
3. Have clear and simple semantics
4. Be intuitive
5. Be easy to memorize
6. Lead to readable code

- read more at e.g., *http://doc.trolltech.com/qq/qq13-apis.html*
- security API even harder: *http://www.cl.cam.ac.uk/~rja14/Papers/SEv2-c18.pdf*
- *http://blog.apigee.com/taglist/security*

Read more about this topics

- Schneier on Security: http://www.schneier.com/
- TaoSecurity http://taosecurity.blogspot.com/
- Krebs on Security: http://krebsonsecurity.com/
- Freedom to Tinker: https://freedom-to-tinker.com/
- Light Blue Touchpaper: http://www.lightbluetouchpaper.org/
- …

Copy-free functions

- API style which minimizes array copy operations
- Frequently used in cryptography
  - we take block, process it and put back
  - can take place inside original memory array
- **int** encrypt**(**byte array**[],** **int** startOffset**,** **int** length**);**
  - encrypt data from *startOffset* to *startOffset* + *length;*
- Wrong(?) example:
  - **int** encrypt**(**byte array**[],** **int** length**,** byte outArray**[],** **int*** pOutLength**);**
  - note: C/C++ can still use pointers arithmetic
  - note: Java can't (we need to create new array)

Block cipher modes for Authenticated Encryption

Modes for authenticated encryption

- Encryption preserves confidentiality but not integrity
- Common integrity functions (like CRC) protect against random faults
- Cryptographic message integrity protects intensional errors

Confidentiality, integrity, privacy

- Message confidentiality [encryption]
  - attacker is not able to obtain info about plaintext
- Message integrity [MAC]
  - attacker is not able to modify message without being detected (PTX, CTX)
- Message privacy [encryption]
  - attacker is not able to distinguish between encrypted message and random string
  - same message is encrypted each time differently

Encryption and MAC composition

- Modes for block ciphers (CBC, CTR, CBC-MAC)
- Compositions (encryption + MAC)
  - encrypt-and-mac [$E_{Ke,Km}(M) = E_{Ke}(M) \mid T_{Km}(M)$]
    - can fail with privacy and authenticity
  - mac-then-encrypt [$E_{Ke,Km}(M) = E_{Ke}(M \mid T_{Km}(M))$]
    - can fail with authenticity
  - encrypt-then-mac [$E_{Ke,Km}(M) = E_{Ke}(M) \| T_{Km}(E_{Ke}(M)$]
    - always provides privacy and authenticity
- Paralelizability issue
- Authenticated-encryption modes (AE)
  - special block cipher modes for composed process

Usage scenarios

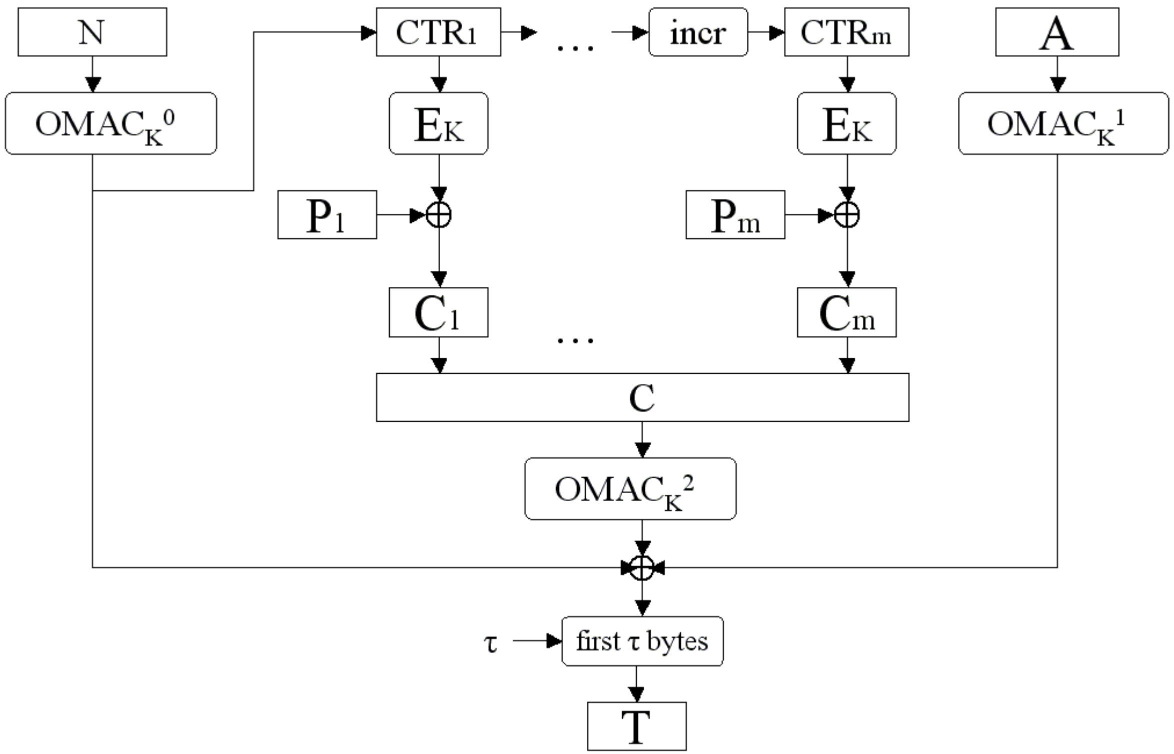
- Powerful, parallelizable environments
  - hardware accelerators
- Powerful, but almost serial environments
  - personal computer, PDA
- Restricted environments
  - smart card, cellular phone
- Different scenarios have different needs

Important features for AE modes

- Provable security
- Performance, paralelizability, memory req.
  - important for high-speed encryption, SC
- Patent
  - early AE modes were patented
- Associated data authentication
  - authentication of non-encrypted part
- Online, incremental MAC, number of keys, endian dependency …
- http://blog.cryptographyengineering.com/2012/05/how-to-choose-authenticated-encryption.html
- www.fi.muni.cz/~xsvenda/docs/AE_comparison_ipics04.pdf

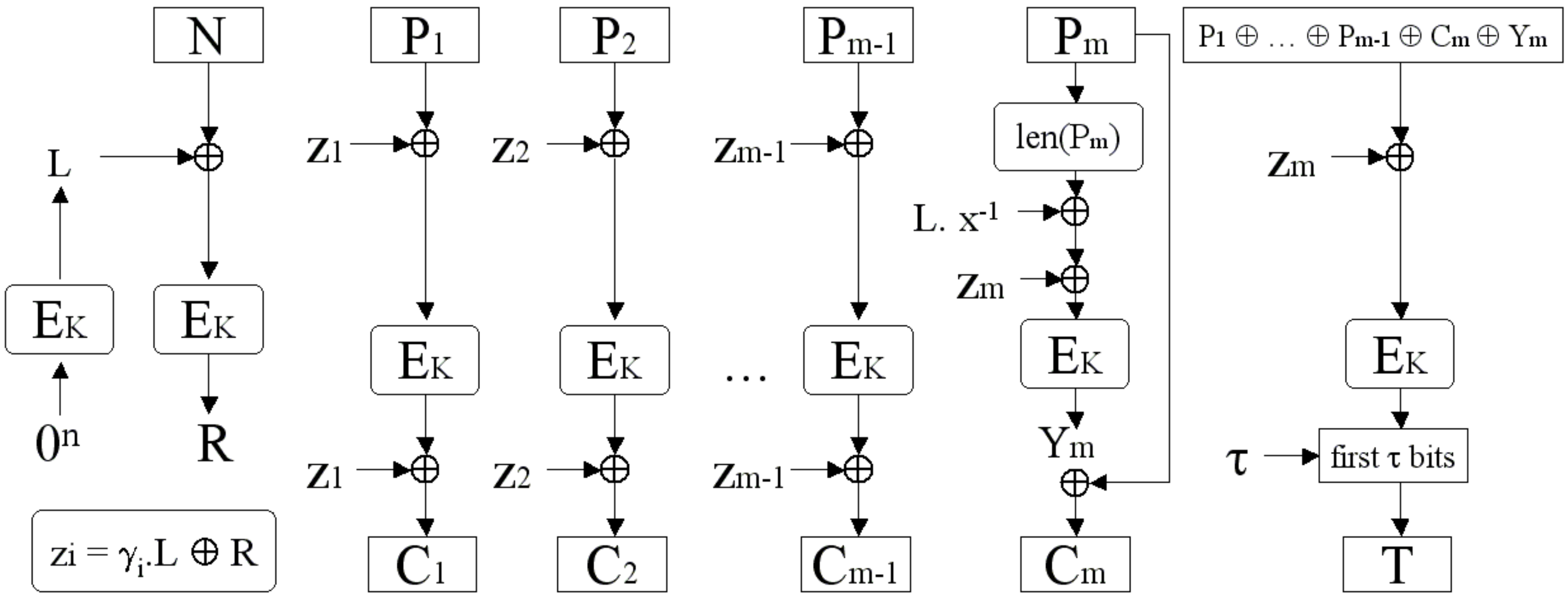
EAX mode

- Encrypt-than-mac composition
- Provable secure, unpatented



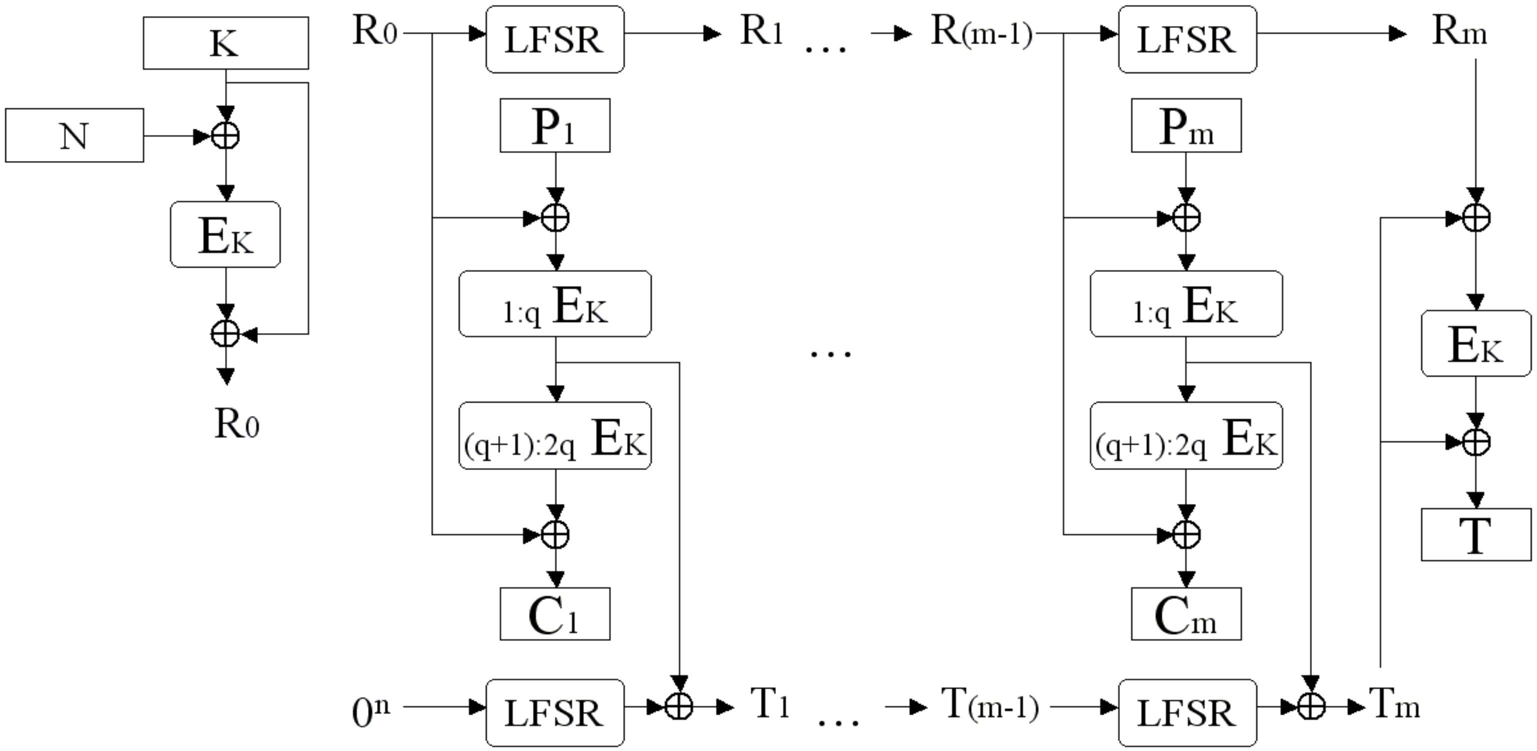
Offset CodeBook mode (OCB)

- Memory efficient, fast mode
- Provable secure, but patented



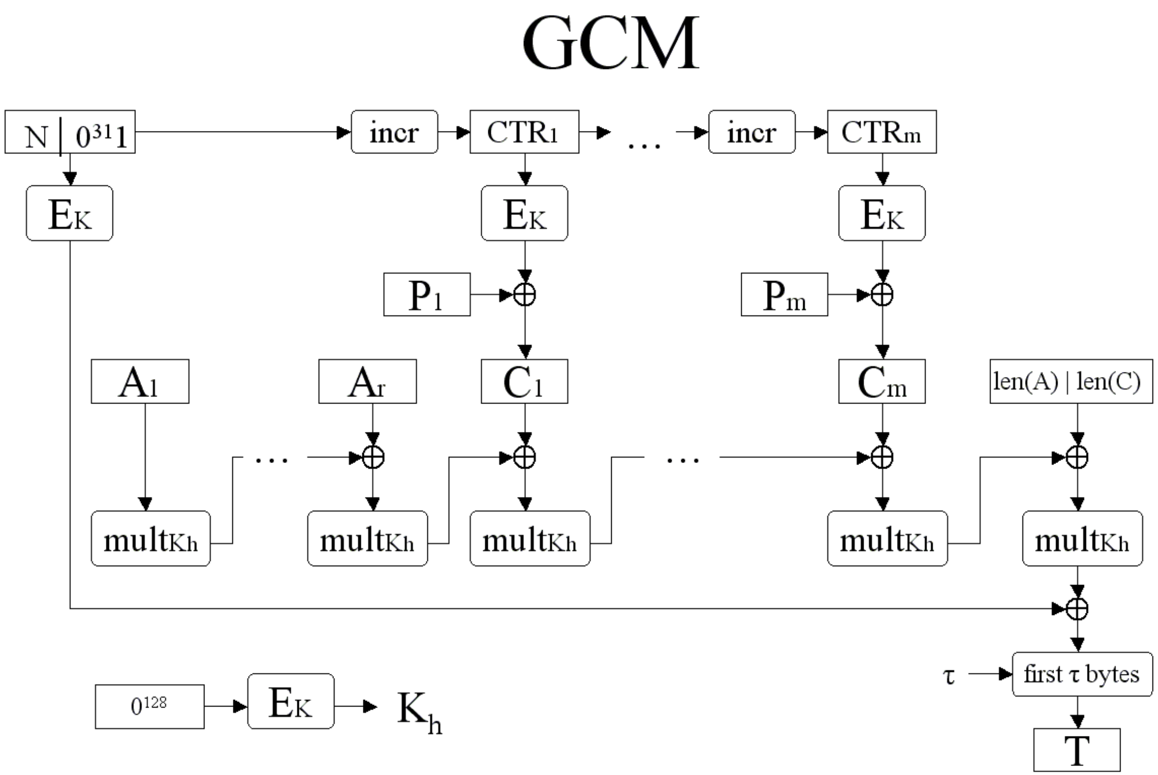
Cipher-State mode (CS)

- Memory efficient, fast mode, unpatented
- Not provable secure (inner state of cipher)



Galois/Counter Mode (GCM)

- Need pre-computed table (4kB-64kB)
- fast mode, provable secure, unpatented, NIST standard
- http://csrc.nist.gov/publications/nistpubs/800-38D/SP-800-38D.pdf



Implementation: AES-GCM from PolarSSL

- gcm.h, gcm.c

```
int gcm_init( gcm_context *ctx,
      const unsigned char *key,
      unsigned int keysize );

int gcm_crypt_and_tag( gcm_context *ctx,
      int mode, // GCM_ENCRYPT (alternatively GCM_DECRYPT)
      size_t length,
      const unsigned char *iv,
      size_t iv_len,
      const unsigned char *add, // authenticated, but not encrypted
      size_t add_len,
      const unsigned char *input, // authenticated and encrypted
      unsigned char *output,      // encrypted data
      size_t tag_len,
      unsigned char *tag );
```

```
int gcm_auth_decrypt( gcm_context *ctx,
      size_t length,              // length of input data
      const unsigned char *iv,
      size_t iv_len,
      const unsigned char *add,  // authenticated, but not encrypted
      size_t add_len,
      const unsigned char *tag,  // authenticator (MAC value)
      size_t tag_len,
      const unsigned char *input, // encrypted data
      unsigned char *output );    // decrypted data
```

CAESAR competition

- http://competitions.cr.yp.to/caesar-submissions.html

Cryptographic competitions

Introduction
Secret-key cryptography
Disasters
Features

Focused competitions:
AES
eSTREAM
SHA-3
PHC
CAESAR

Broader evaluations:
CRYPTREC
NESSIE

CAESAR details:
Submissions
Call for submissions
Call draft 5
Call draft 4
Call draft 3
Call draft 2
Call draft 1
Committee
Frequently asked questions

CAESAR submissions

candidate	designers
ACORN: v1	Hongjun Wu
++AE: v1.0 analysis parameters	Francisco Recacha
AEGIS: v1	Hongjun Wu, Bart Preneel
AES-CMCC: v1 v1.1	Jonathan Trostle
~~AES-COBRA~~: v1 withdrawn	Elena Andreeva, Andrey Bogdanov, Martin M. Lauridsen, Atul Luykx, Bart Mennink, Elmar Tischhauser, Kan Yasuda
AES-COPA: v1	Elena Andreeva, Andrey Bogdanov, Atul Luykx, Bart Mennink, Elmar Tischhauser, Kan Yasuda
AES-CPFB: v1	Miguel Montes, Daniel Penazzi
AES-JAMBU: v1	Hongjun Wu, Tao Huang
AES-OTR: v1	Kazuhiko Minematsu
AEZ: v1 security	Viet Tung Hoang, Ted Krovetz, Phillip Rogaway
Artemia: v1 proof addendum	Javad Alizadeh, Mohammad Reza Aref, Nasour Bagheri
Ascon: home v1	Christoph Dobraunig, Maria Eichlseder, Florian Mendel, Martin Schläffer
AVALANCHE: v1 corrections	Basel Alomair
Calico: v8	Christopher Taylor
CBA: v1 v1-1	Hossein Hosseini, Shahram Khazaei
~~CBEAM~~: r1 withdrawn	Markku-Juhani O. Saarinen
CLOC: v1	Tetsu Iwata, Kazuhiko Minematsu, Jian Guo, Sumio Morioka

Conclusions

- Composition of ENC and MAC can fail
  - encrypt-then-mac provable secure
  - specially designed composed modes
- Most promising mode is patented (OCB)
  - fast alternative GCM, CS
  - Searching for new modes (CAESAR competition)
- Suitable mode depends on usage
  - parallelizability, memory
  - specific needs (online, incremental MAC)