CrypTool

A free software program

- **for creating awareness of IT security issues**
- **for learning about and obtaining experience of cryptography**
- **for demonstrating encryption algorithms and analysis procedures**

www.cryptool.de
www.cryptool.com
www.cryptool.org

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Contents

Introduction

1. What is CrypTool?

- a freeware Program with graphical user interface
- a tool for applying and analysing cryptographic algorithms
- with extensible online help, understandable without deep crypto knowledge
- contains nearly all state of the art crypto algorithms
- “playful” introduction to modern and classical cryptography
- not a “hacker tool”

2. Why CrypTool?

- origin in Deutsche Bank’s IT security awareness program
- developed in co-operation with universities
- improve IT security related courses in universities and companies

3. Audience

- target group: students of computer science, commercial IT and mathematics
- also for: interested computer users and application developers
- prerequisites: secondary school mathematics or programming skills

CrypTool Overview
1. Features

Cryptography

Classical algorithms

- Caesar
- Vigenère
- Hill
- Monoalphabetic substitution
- Homophonic substitution
- Playfair
- Permutation
- Addition
- XOR
- Vernam

To facilitate performing text book examples with CrypTool

- alphabet can be configured
- treatment of white space etc. configurable

Cryptoanalysis

Attacks on classical algorithms

- ciphertext only
  - Caesar
  - Vigenère
  - Addition
  - XOR
- known plaintext
  - Hill
  - Playfair
- manual
  - mono-alphabetic substitution

Supporting analysis procedures

- entropy, floating frequency
- histogram, n-gram analysis
- auto-correlation
- ZIP compression test

CrypTool Overview
1. Features

Cryptography

Modern symmetric algorithms

- IDEA, RC2, RC4, DES, 3DES
- last round AES candidates
- AES (=Rijndael)

Asymmetric algorithms

- RSA with X.509 certificates
- RSA demonstration
  - to facilitate performing text book examples with CrypTool
  - alphabet and block length configurable

Hybrid encryption

- RSA combined with AES encryption
- visualised by an interactive data flow diagram

Cryptoanalysis

Brute force attack on symmetric algorithms

- implemented for all algorithms
- assumption:
  entropy of plain text small
- search space limited to 20 bit

Attack on RSA encryption

- factor RSA modulus
- workable for bit lengths <= 250

Attack on hybrid encryption

- attack on RSA (see below) or
- attack on AES (see above)

CrypTool Overview
1. Features

Cryptography

Digital Signature

- RSA with X.509 certificates
  - signature procedure visualised by an interactive data flow diagram
- DSA with X.509 certificates
- Elliptic Curve DSA, Nyberg-Rueppel

Hash functions

- MD2, MD4, MD5
- SHA, SHA-1, RIPEMD-160

Random generators

- SECUDE
- X^2 modulo N
- Linear Congruence Generator (LCG)
- Inverse Congruence Generator (ICG)

Cryptoanalysis

Attack on RSA Signature

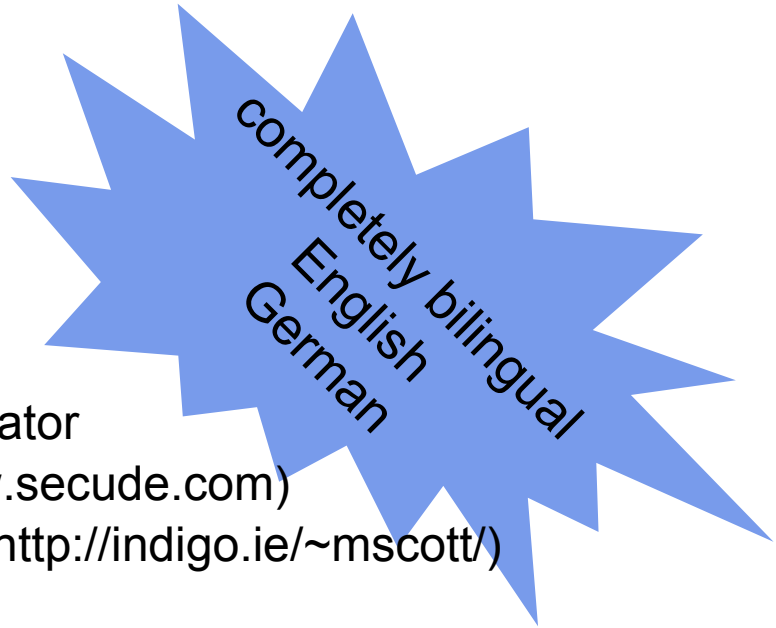
- RSA module factorisation
- workable up to approx. 250 bit

No attack implemented

Random data analysis

- FIPS-PUB-140-1 test battery
- periodicity, Vitany, entropy
- histogram, n-gram analysis
- auto-correlation
- ZIP compression test

CrypTool Overview
2. Software package contents



CrypTool program

- all functions integrated in *one* program with uniform graphical user interface
- platforms: Win32 and Linux with WINE emulator
- cryptography based on Secude library (www.secude.com)
- arbitrary precision arithmetic: Miracl library (http://indigo.ie/~mscott/)

AES-Tool

- standalone program for AES encryption

Extensive online help (Winhelp)

- context sensitive online help for *all* program functions
- detailed usage examples for many program features

Script (PDF) with background information on

- encryption algorithms • prime numbers • digital signature
- elliptic curves • public key certification • elementary number theory

Short story “Dialogue of the Sisters” by Dr. C. Elsner

CrypTool Overview
3. New in release 1.3.xx

Most important changes (details: see ReadMe-en.txt):

Release 1.3.00 published January 2002

- completely bilingual English/German
- dialog box consistency and comprehensibility improved
- Windows 9x file size limit removed
- homophonic and permutation encryption
- random generators, random data analysis (FIPS-140-1, periodicity, n-gram)
- AES-Tool: create self-decrypting files (AES)
- demonstration: number theory and RSA crypto system (further improved in 1.3.03)
- PKCS#12 export/import for PSEs

Release 1.3.03 published August 2002

- visualisation of hybrid encryption and decryption
- visualisation of signature creation and verification
- hash value calculation of large files (without loading them into memory)
- visualisation of the sensitivity of hash functions to changes in the hashed data
- short story “Dialogue of the Sisters” by Dr. C. Elsner included

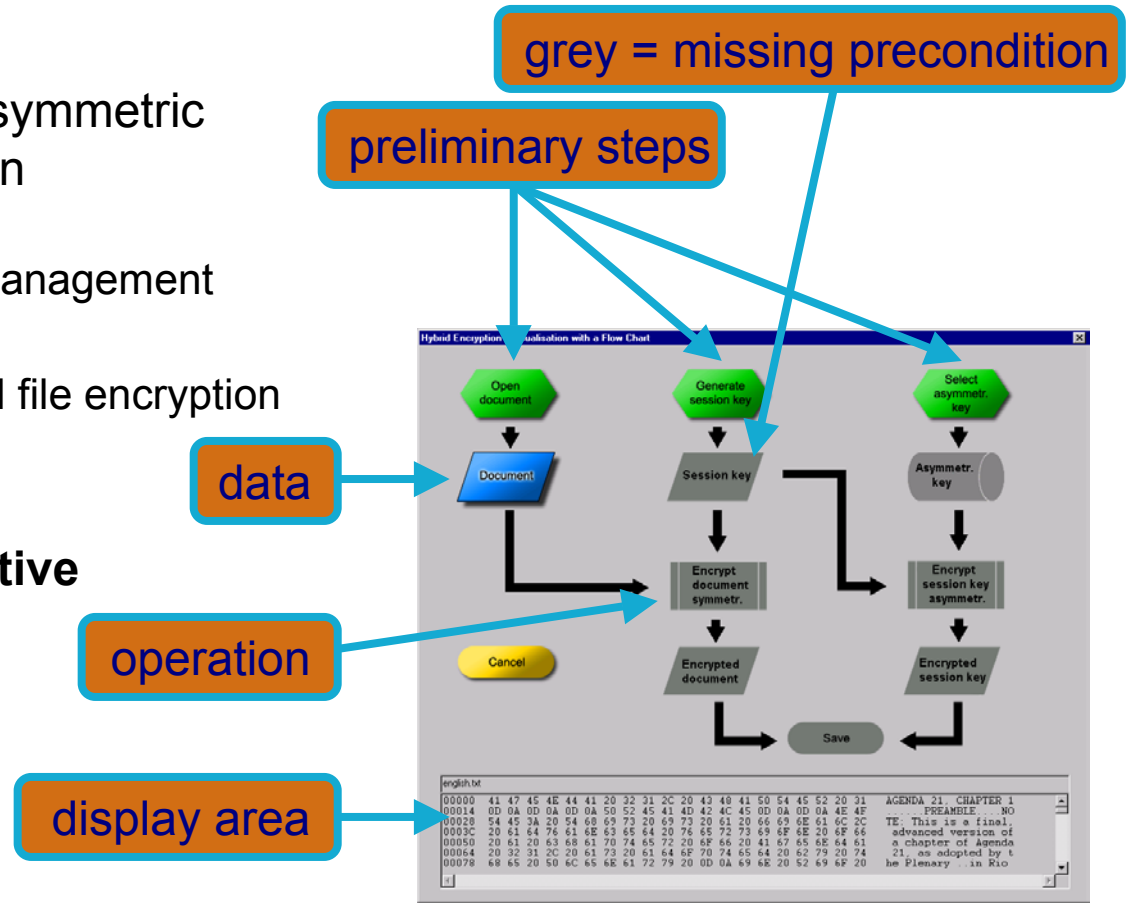
Examples of use
1. Hybrid encryption visualised

Hybrid encryption

- combines advantages of symmetric and asymmetric encryption
  - speed
  - simple and scalable key management
- widely used in practice
  - e-mail (S/MIME, PGP) and file encryption
  - SSL (https)

Visualisation by an interactive data flow diagram

- playful learning leads to deeper understanding



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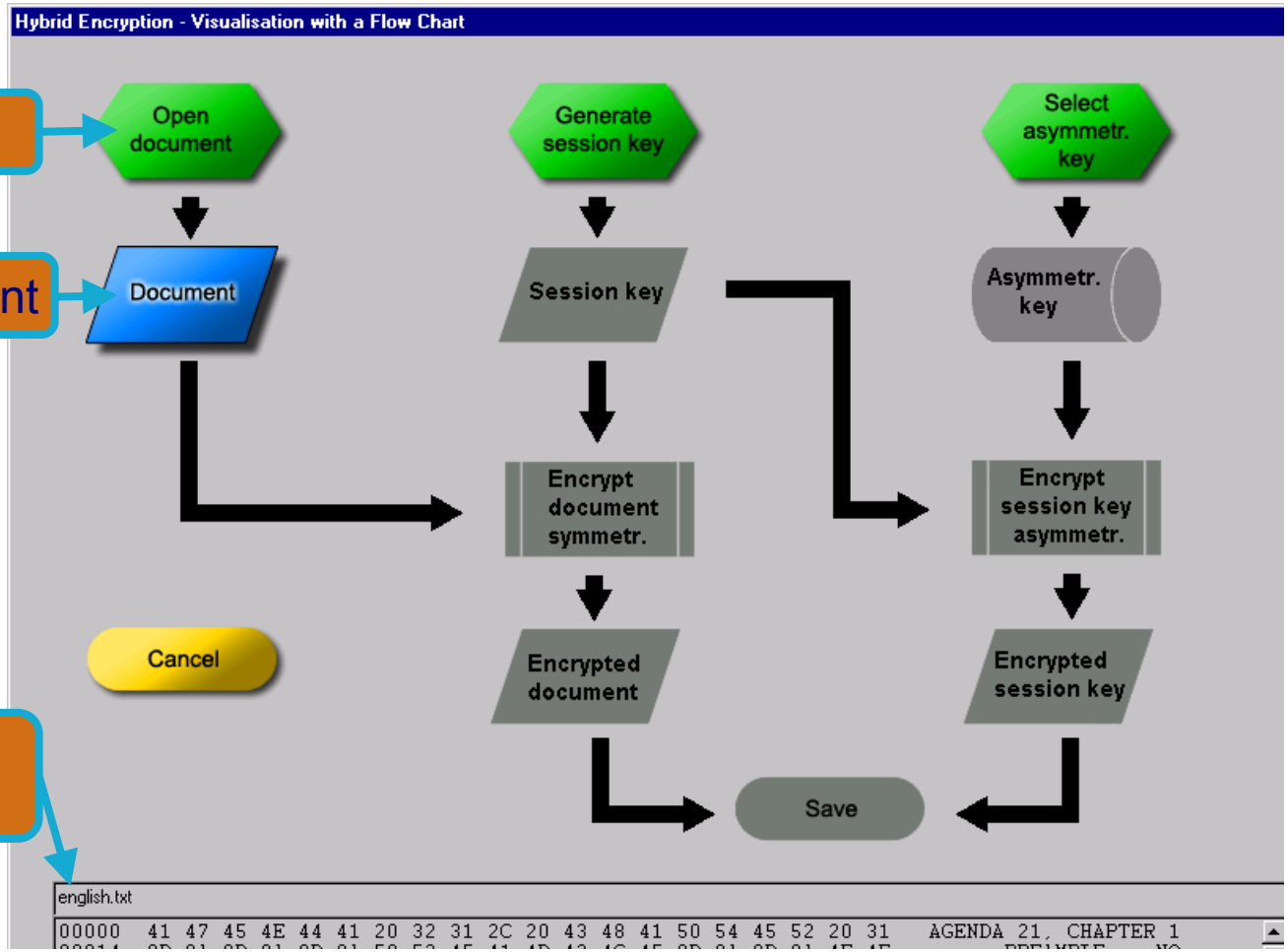
Examples of use
1. Hybrid encryption visualised: Preparation

1. select file

2. click on document

3. contents displayed here



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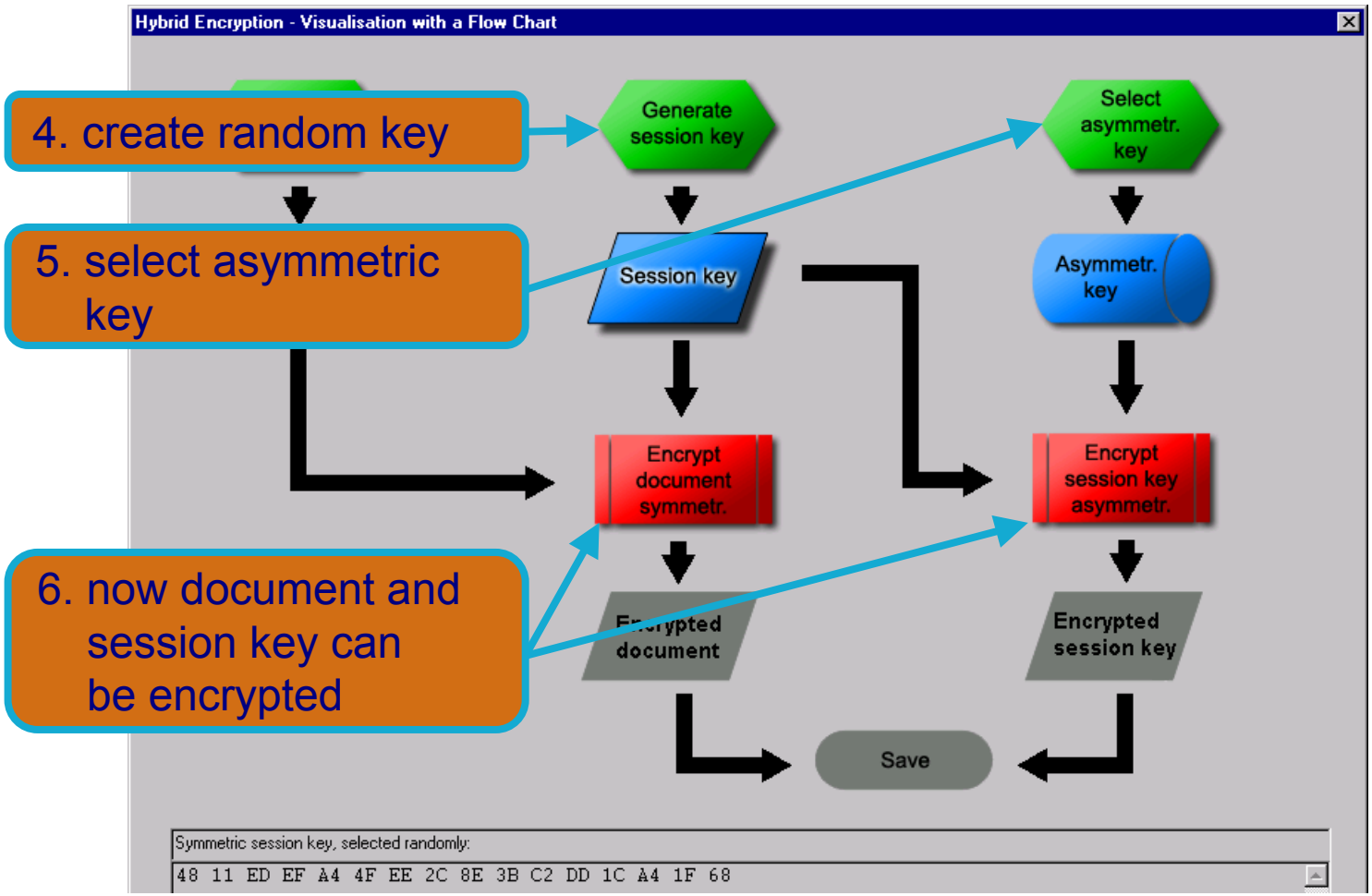
Examples of use
1. Hybrid encryption visualised: Cryptography



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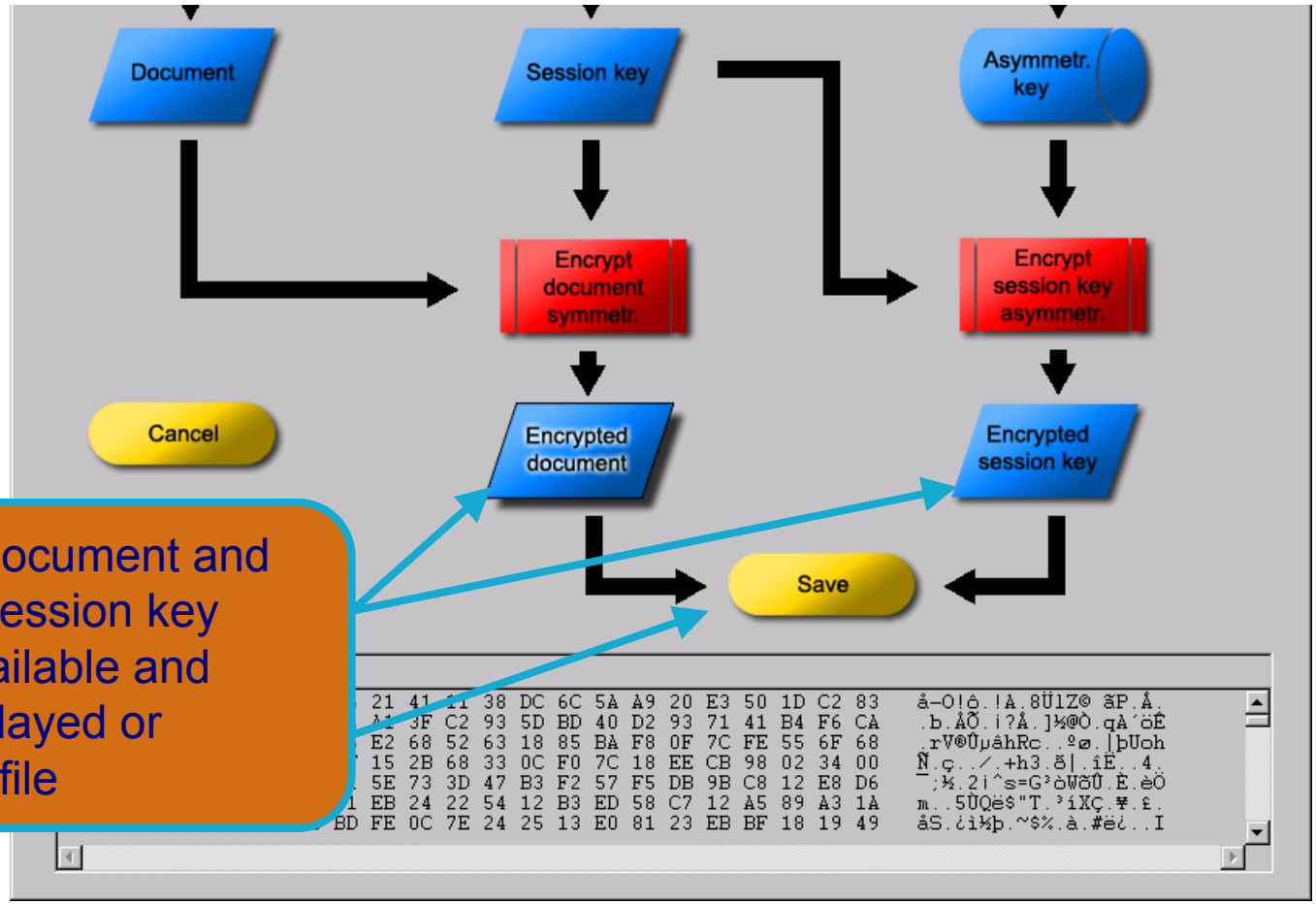
Examples of use
1. Hybrid encryption visualised: Result



7. encrypted document and encrypted session key are now available and can be displayed or written to a file

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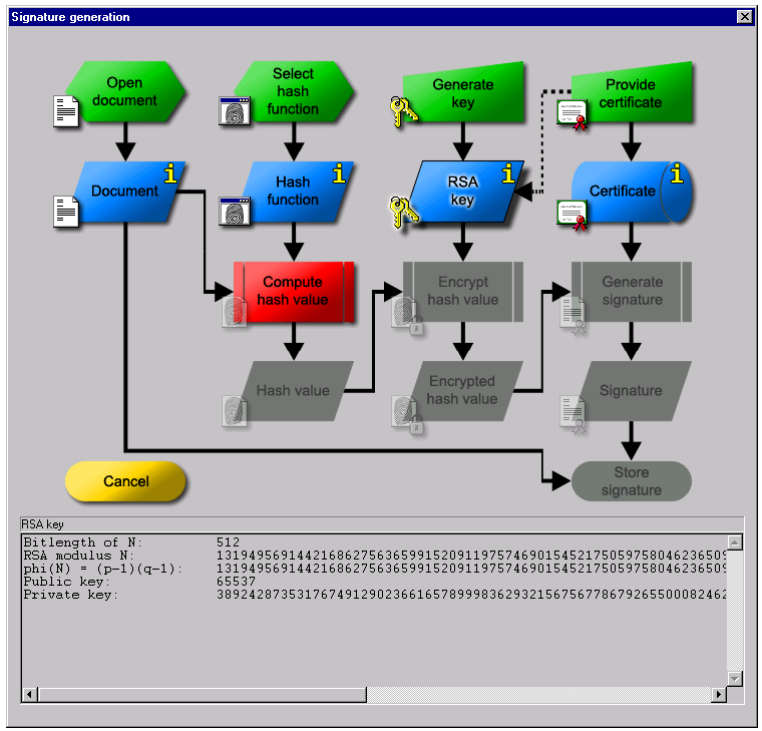
Examples of use
2. Digital signature visualised

Digital signature

- increasingly important
  - equivalence with manual signature (digital signature law)
  - more and more used by industry, government and consumers
- few people know how it works

Visualisation in CrypTool

- interactive data flow diagram
- similar to the visualisation of hybrid encryption



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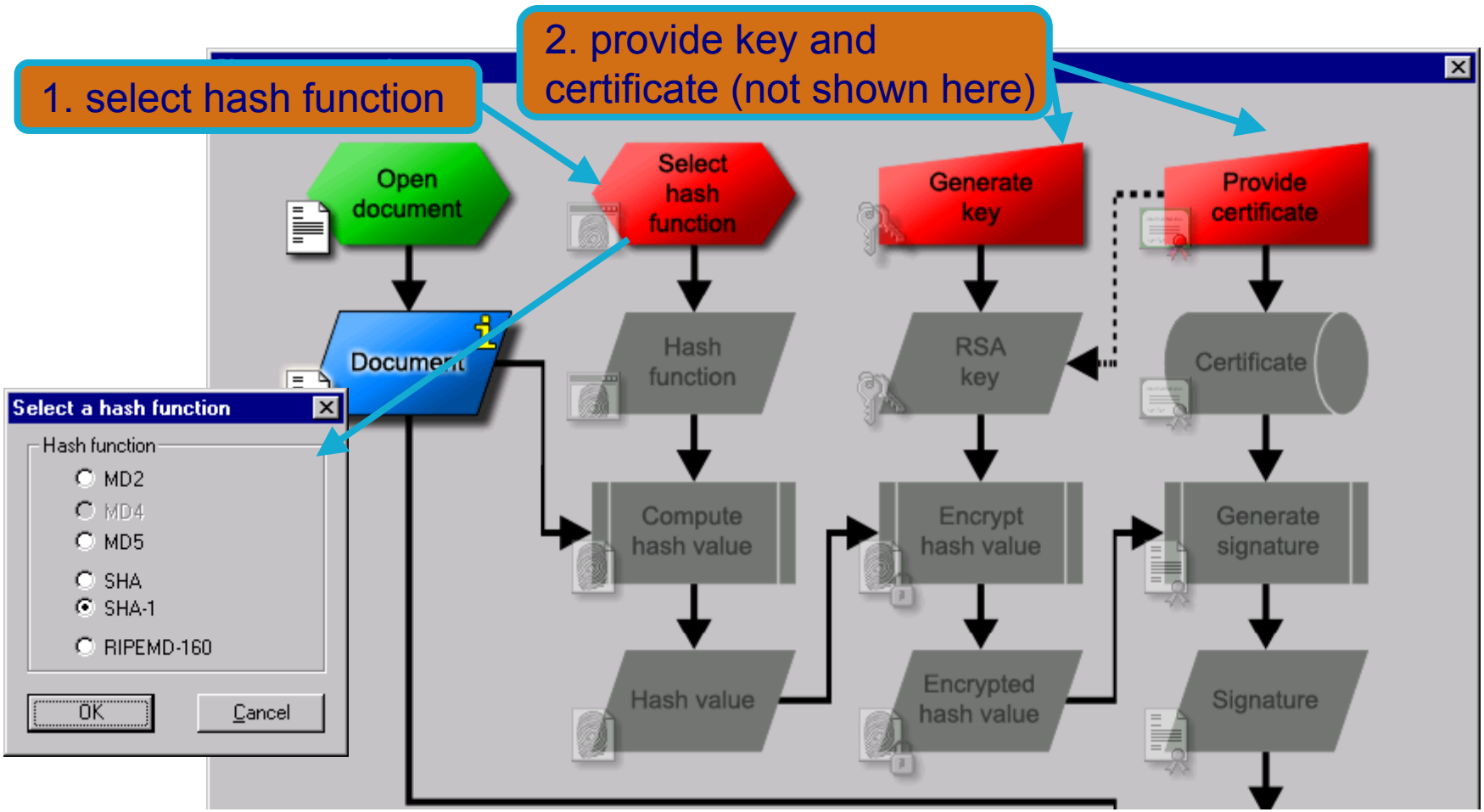
Examples of use
2. Digital signature visualised: Preparation



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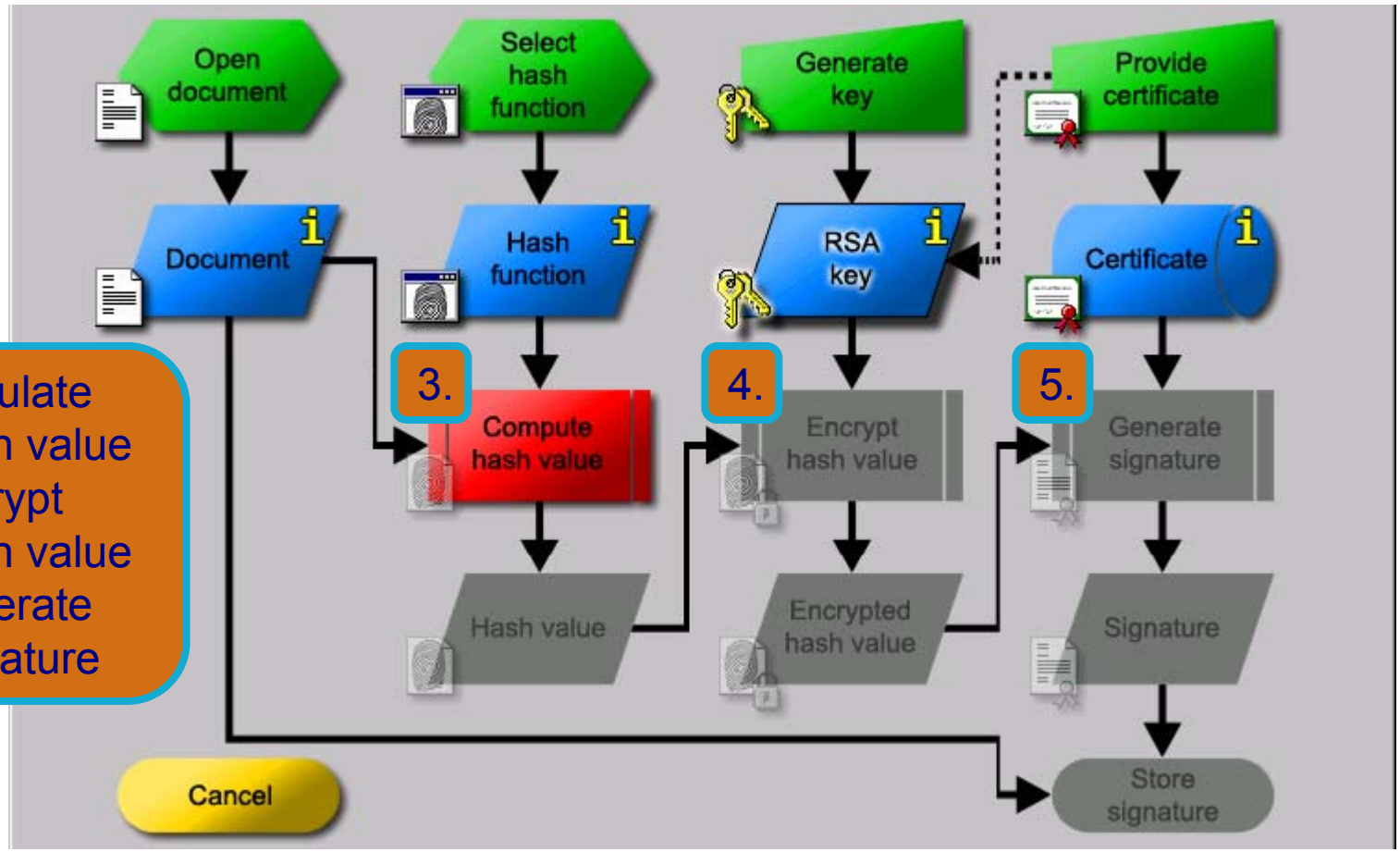
Examples of use
2. Digital signature visualised: Cryptography

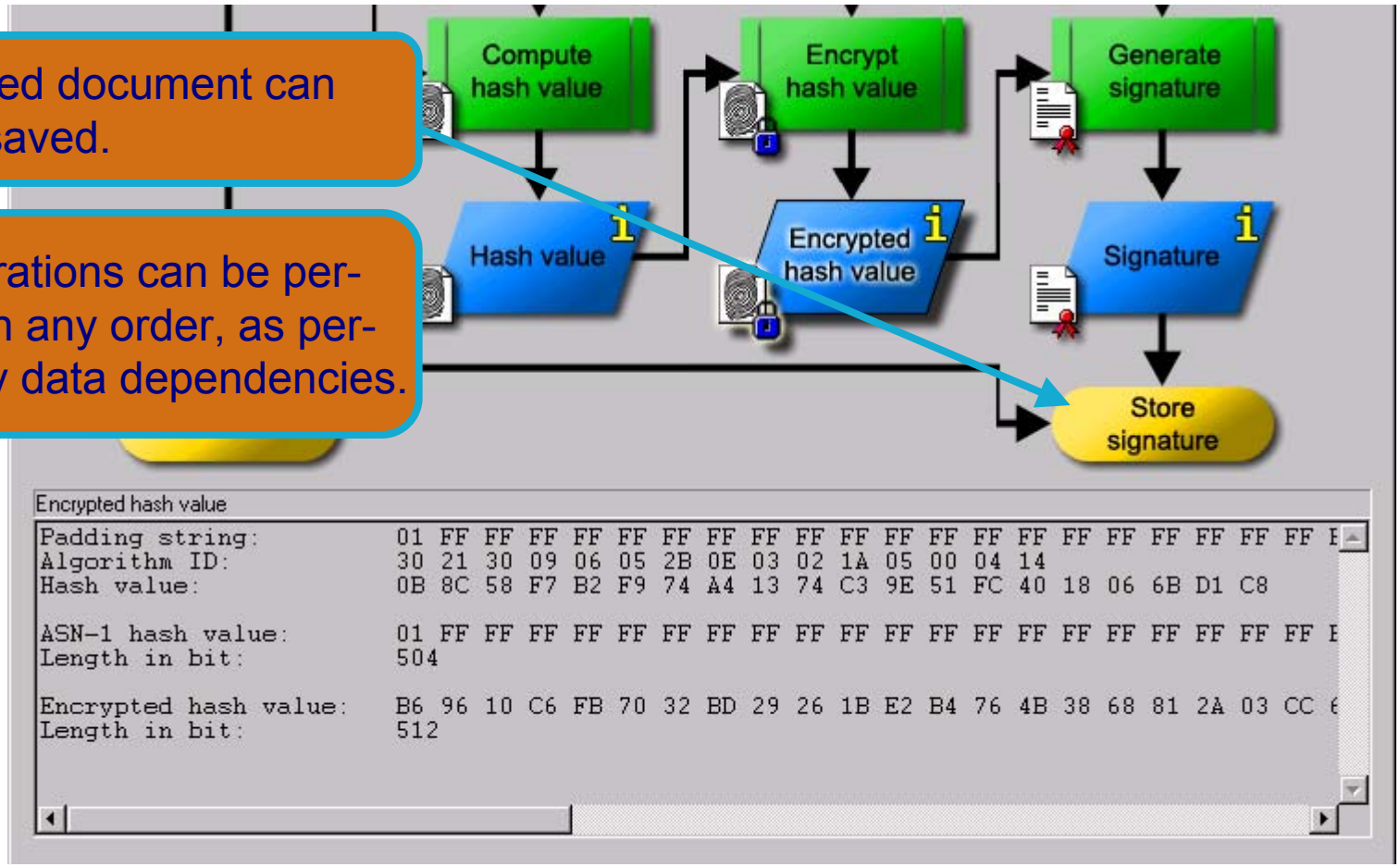


3. calculate hash value
4. encrypt hash value
5. generate signature

Examples of use
2. Digital signature visualised: Result

The signed document can now be saved.

The operations can be performed in any order, as permitted by data dependencies.



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Examples of use
3. Attack on RSA encryption with short RSA modulus

Example from *Song Y. Yan*, Number Theory for Computing, Springer, 2000

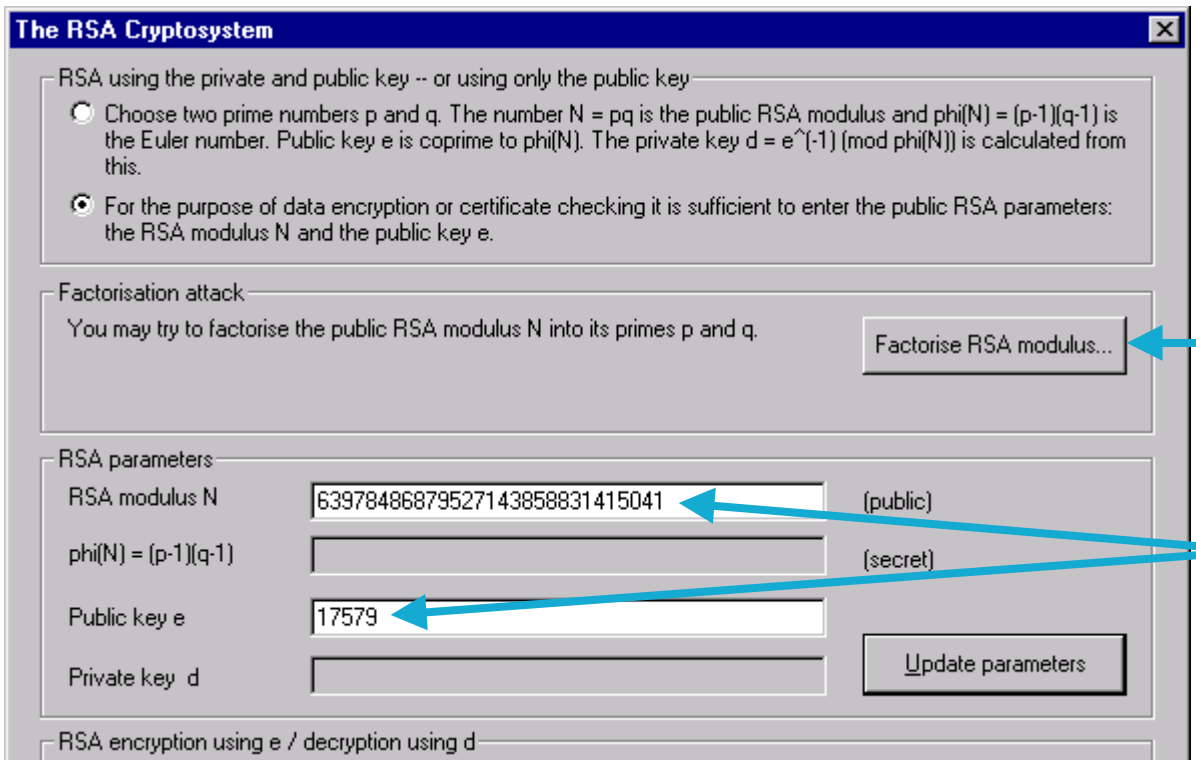
- public key
  - RSA modulus (95bit) N = 639784868795271438588314150 41
  - public exponent e = 17579
- cipher text (block length = 14):
  - C_1 = 45411667895024938209259253423,
    C_2 = 16597091621432020076311552201,
    C_3 = 46468979279750354732637631044,
    C_4 = 32870167545903741339819671379
- the text shall be deciphered!

Solution using CrypTool (more detailed in online help examples section):

- enter public parameters into “RSA cryptosystem” (menu indiv. procedures)
- button “factorise the RSA modulus” yields prime factors p and q where pq = N
- based on that information private exponent $d=e^{-1} \bmod (p-1)(q-1)$ is determined
- decrypt the cipher text with d: $M_i = C_i^d \bmod N$

The attack with CrypTool is workable for RSA moduli up to 250 bit

Examples of use:
3. Short RSA modulus: enter public RSA parameters



2. factorise

1. enter RSA parameters N and e

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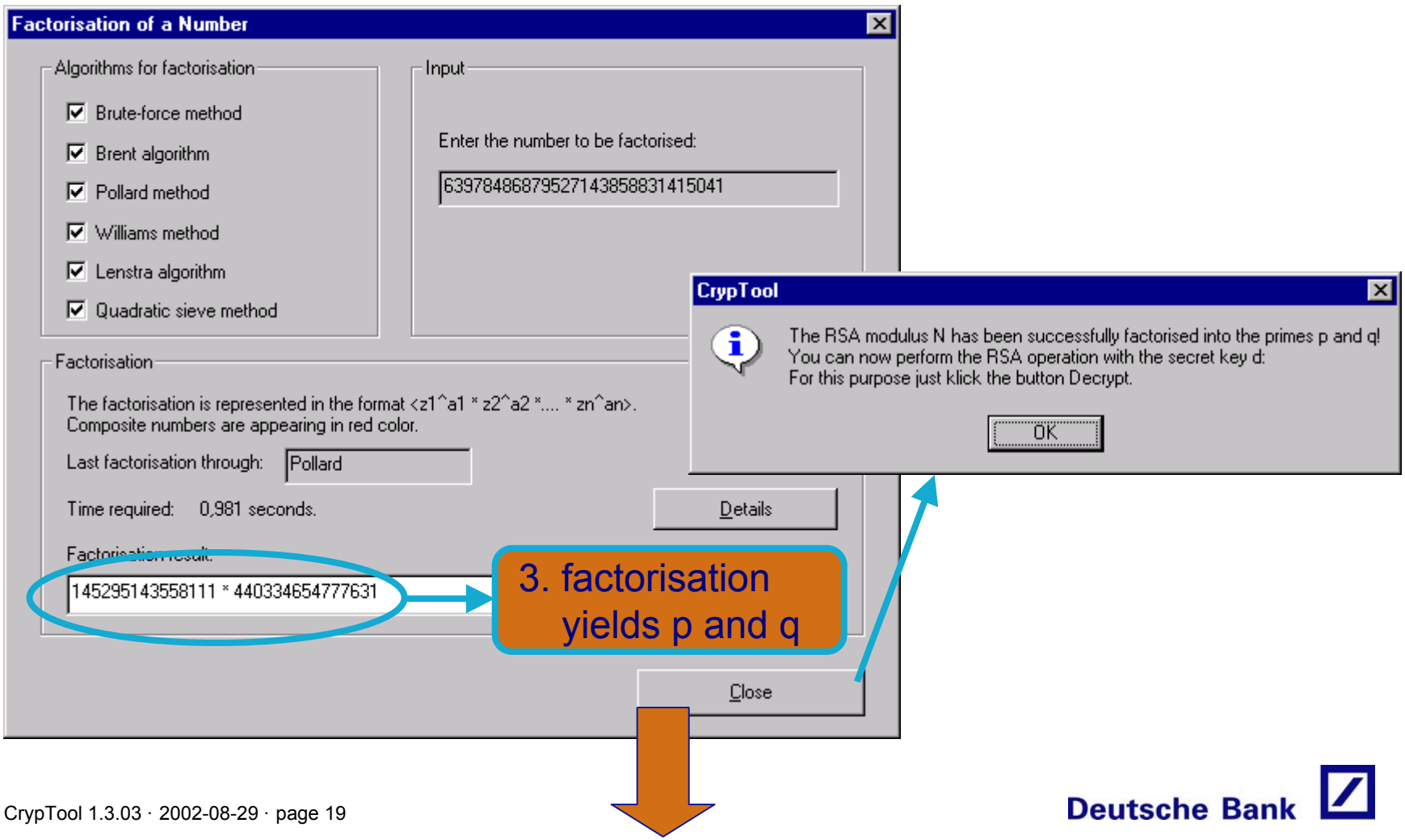
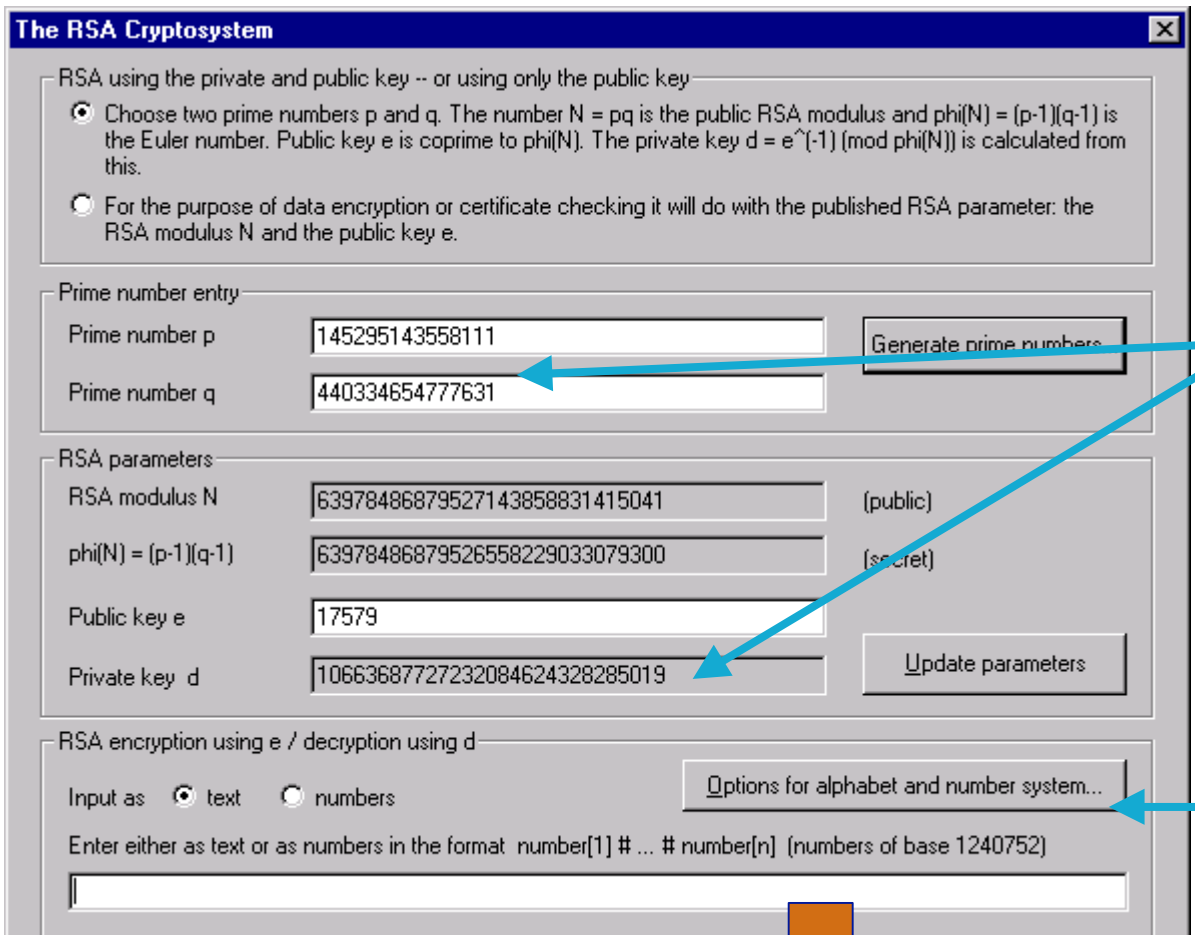
Examples of use:
3. Short RSA modulus: factorise RSA modulus



Examples of use:
3. Short RSA modulus: determine private key d



4. p and q have been entered automatically and secret key d has been calculated

5. adjust options

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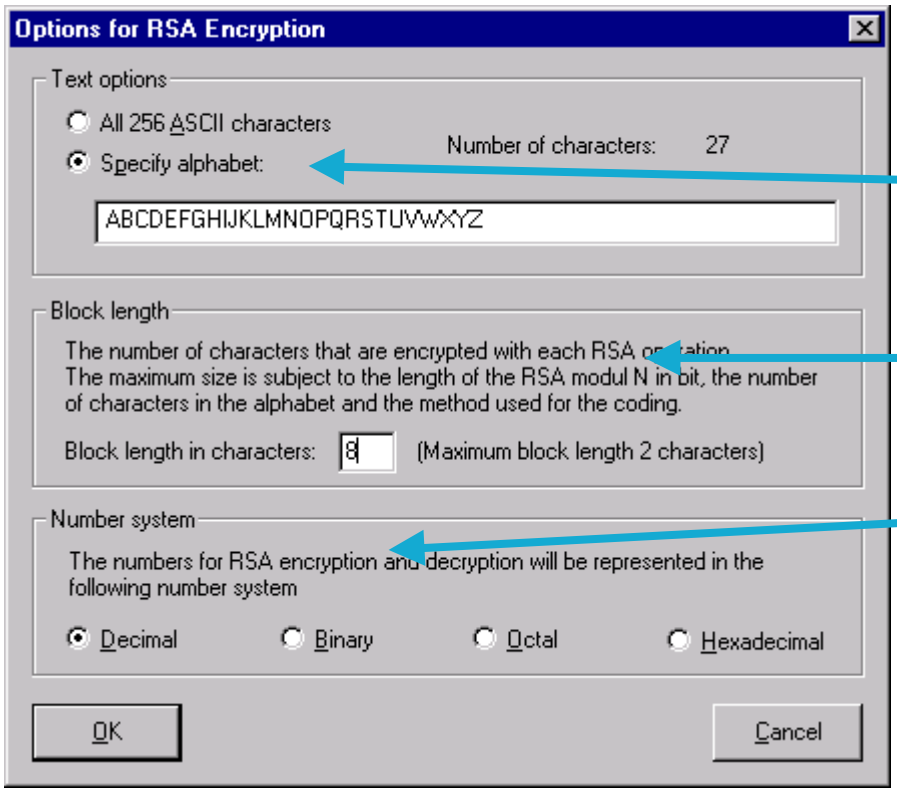
Examples of use:
3. Short RSA modulus: adjust options



6. select alphabet

7. select coding method

8. select block length

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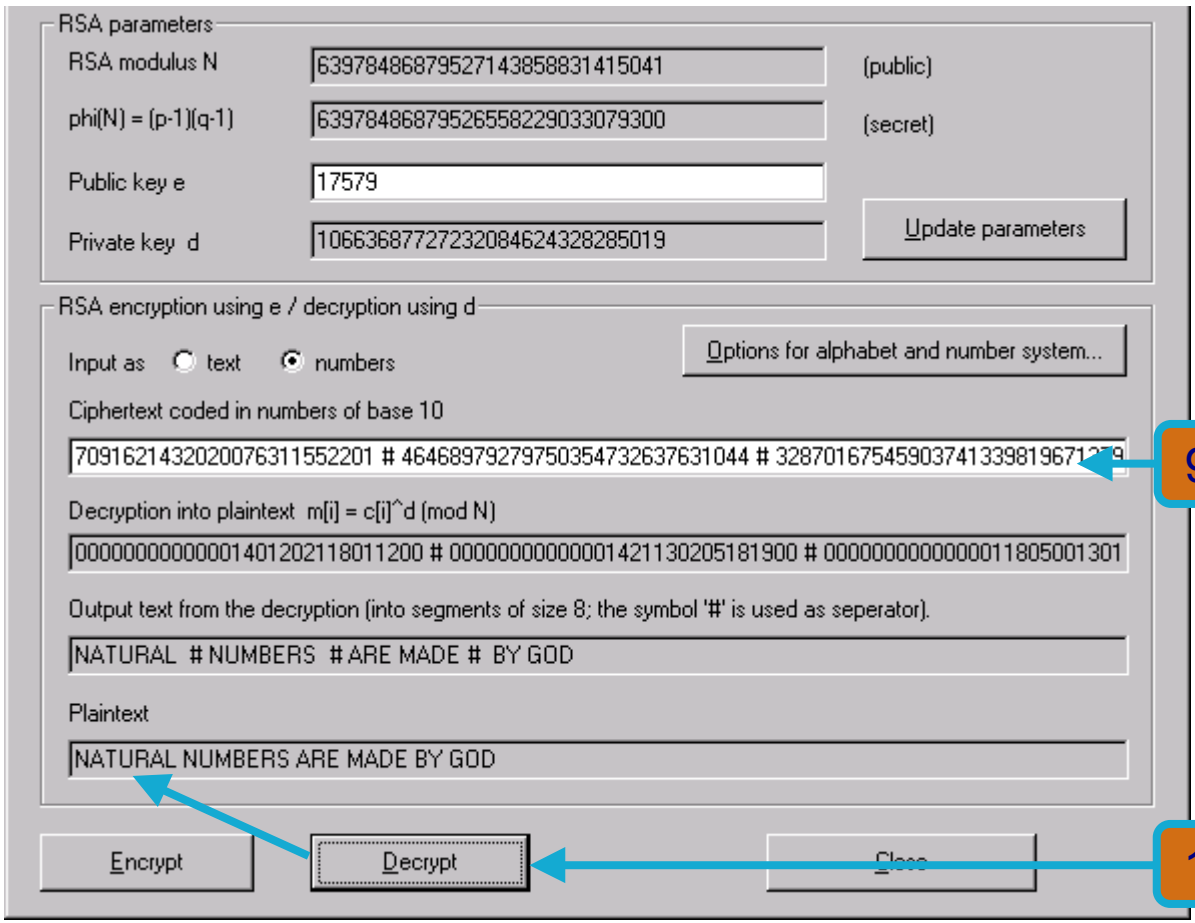
Examples of use:
3. Short RSA modulus: decrypt cipher text



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Examples of use
4. Analysis of encryption used in the PSION 5 PDA

Attack on the encryption option in the PSION 5 PDA word processing application

Starting point: an encrypted file on the PSION

Requirements

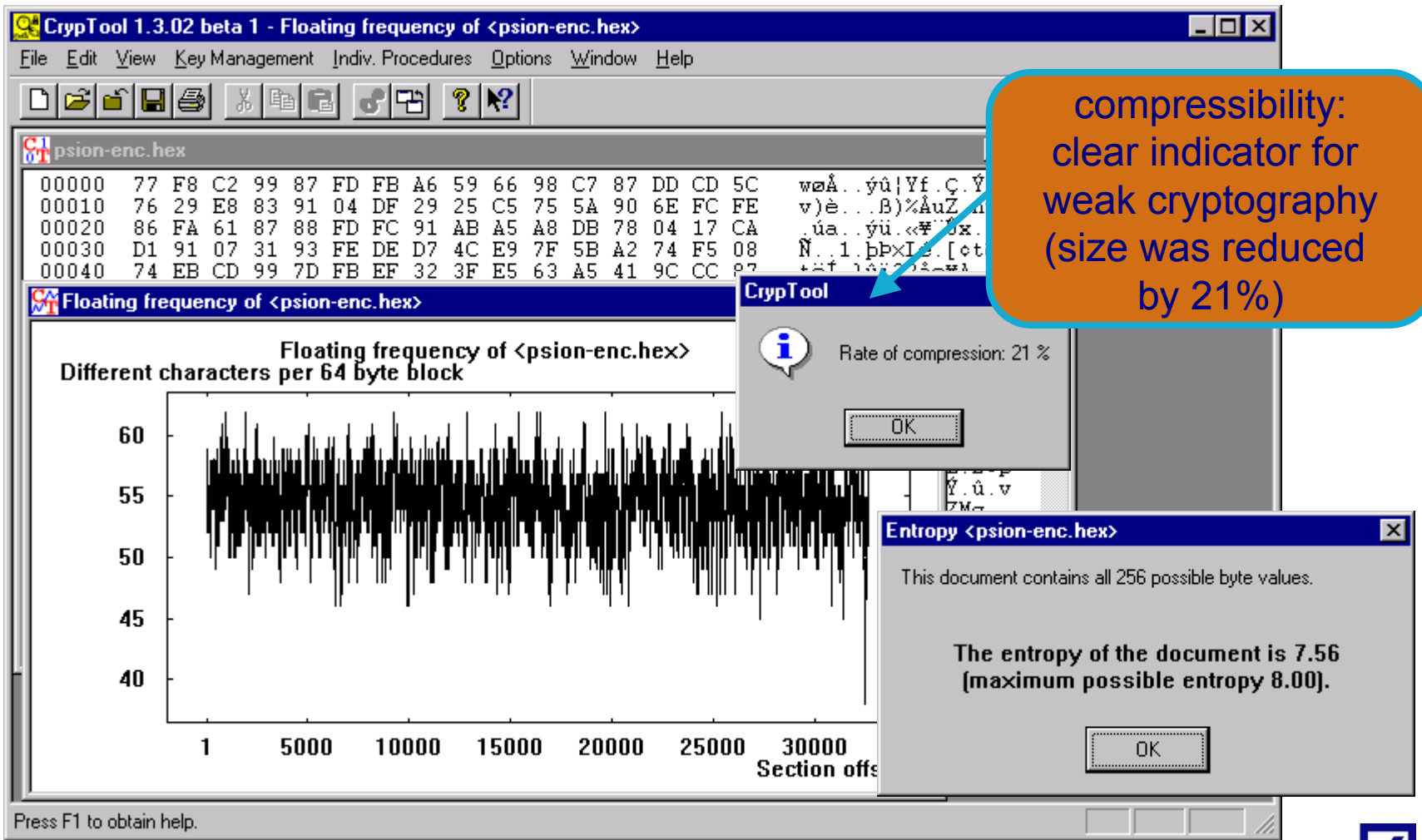
- encrypted English or German text
- depending on method and key length, 100 bytes up to several kB of text

Procedure

- pre-analysis
  - entropy
  - floating entropy
  - compression test

  } ⇒ probably classical encryption algorithm
- auto-correlation
- try out automatic analysis with classical methods

Examples of use
4. PSION PDA: determine entropy, compression test



compressibility: clear indicator for weak cryptography (size was reduced by 21%)

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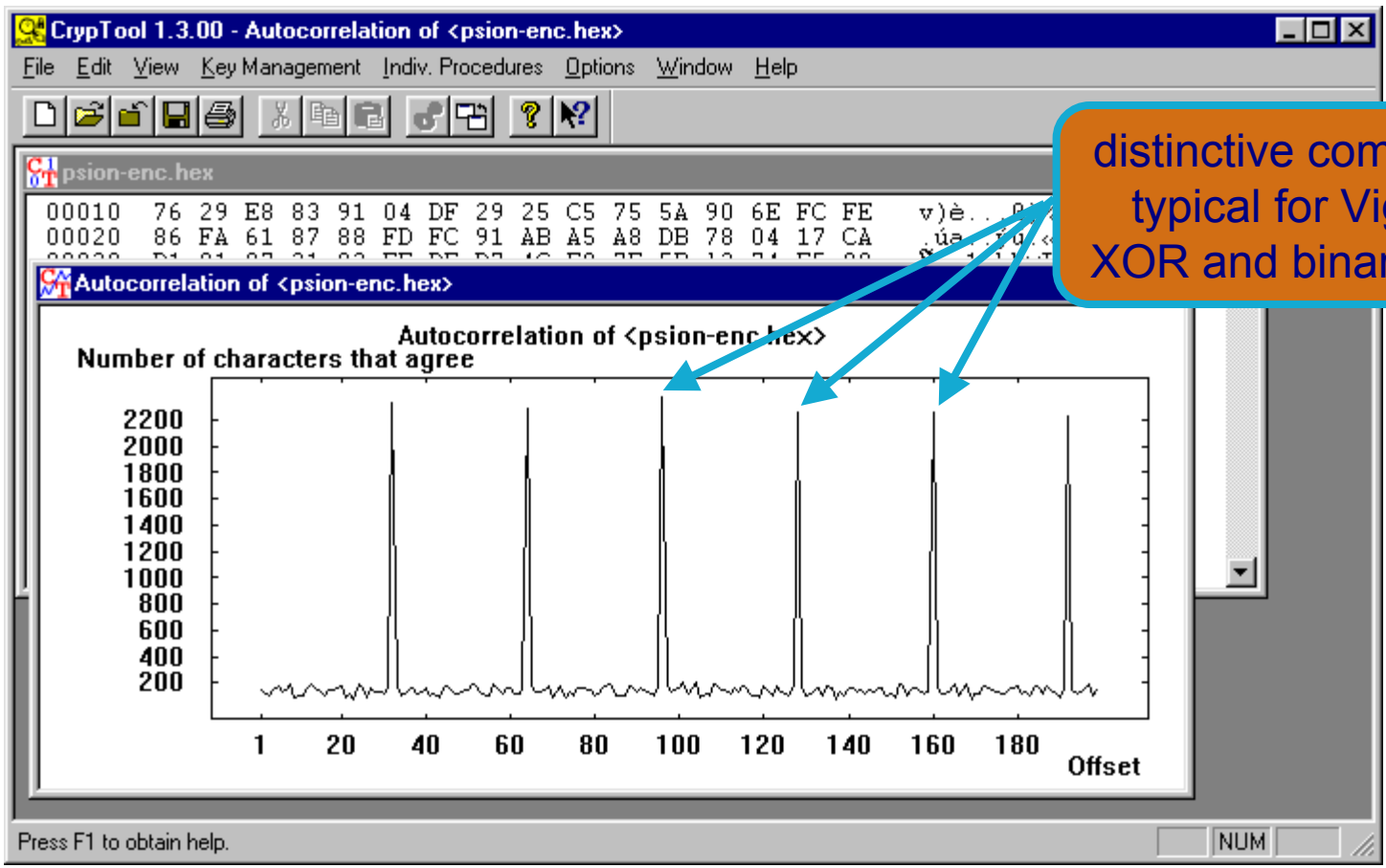
Examples of use
4. PSION PDA: determine auto-correlation



distinctive comb pattern: typical for Vigenère, XOR and binary addition

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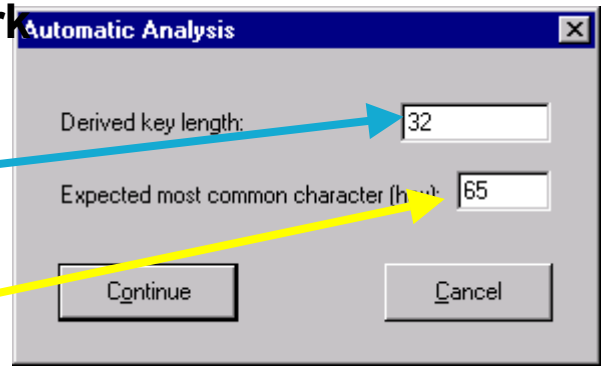
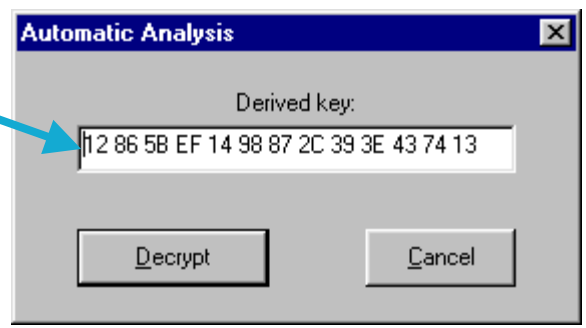
Examples of use
4. PSION PDA: automatic analysis

Automatic analysis using XOR: does not work

Automatic analysis using Binary Addition:

- CrypTool calculates the key length using auto-correlation: 32 bytes
- The user can choose which character is expected to occur most frequently: “e” = 0x65 (ASCII code)
- Analysis calculates the most likely key (based on the assumptions about distribution)
- Results: good, but not perfect





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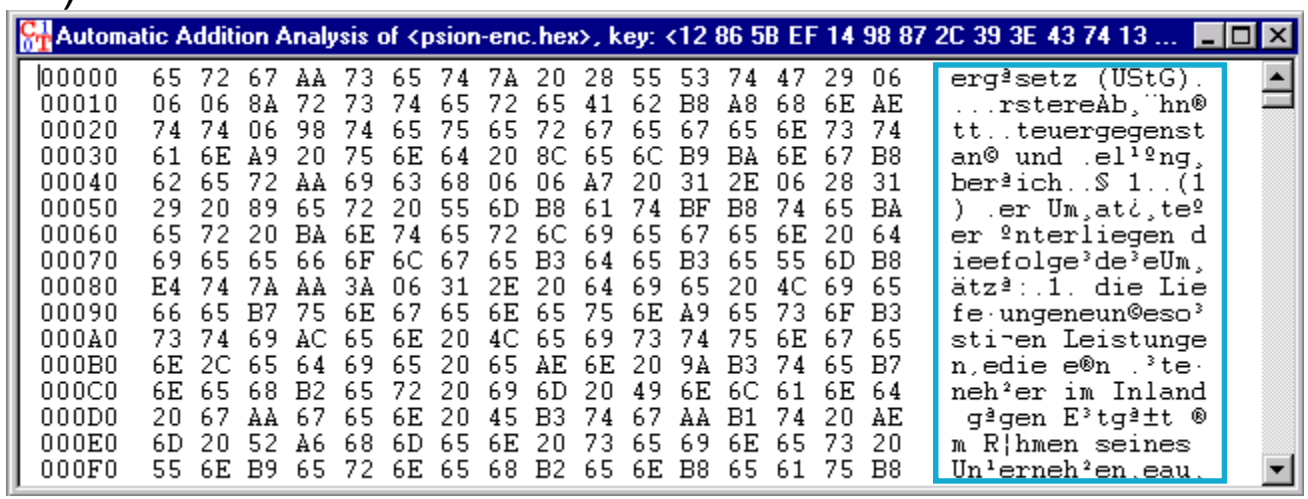
Examples of use
4. PSION PDA: results of automatic analysis

Results of automatic analysis with assumption “binary addition”:

- results good, but not perfect: 24 out of 32 key bytes correct.
- the key length was correctly determined.
- the password entered was not 32 bytes long.
  ⇒ PSION Word derives the actual key from the password.
- manual post-processing produces the encrypted text
  (not shown)



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Examples of use
4. PSION PDA: determining the remaining key bytes

Copy key to clipboard during automatic analysis

In automatic analysis hexdump,

- determine incorrect byte positions, e.g. 0xAA at position 3
- guess and write down corresponding correct bytes: „e“ = 0x65

In encrypted initial file hexdump,

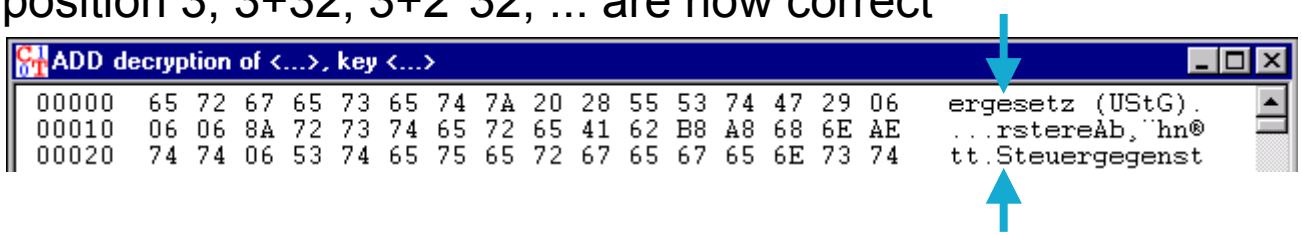
- determine initial bytes from the calculated byte positions: 0x99
- calculate correct key bytes with CALC.EXE: 0x99 - 0x65 = 0x34

Correct key from the clipboard

- 12865B341498872C393E43741396A45670235E111E907AB7C0841...

Decrypt encrypted initial document using binary addition

- bytes at position 3, 3+32, 3+2*32, ... are now correct



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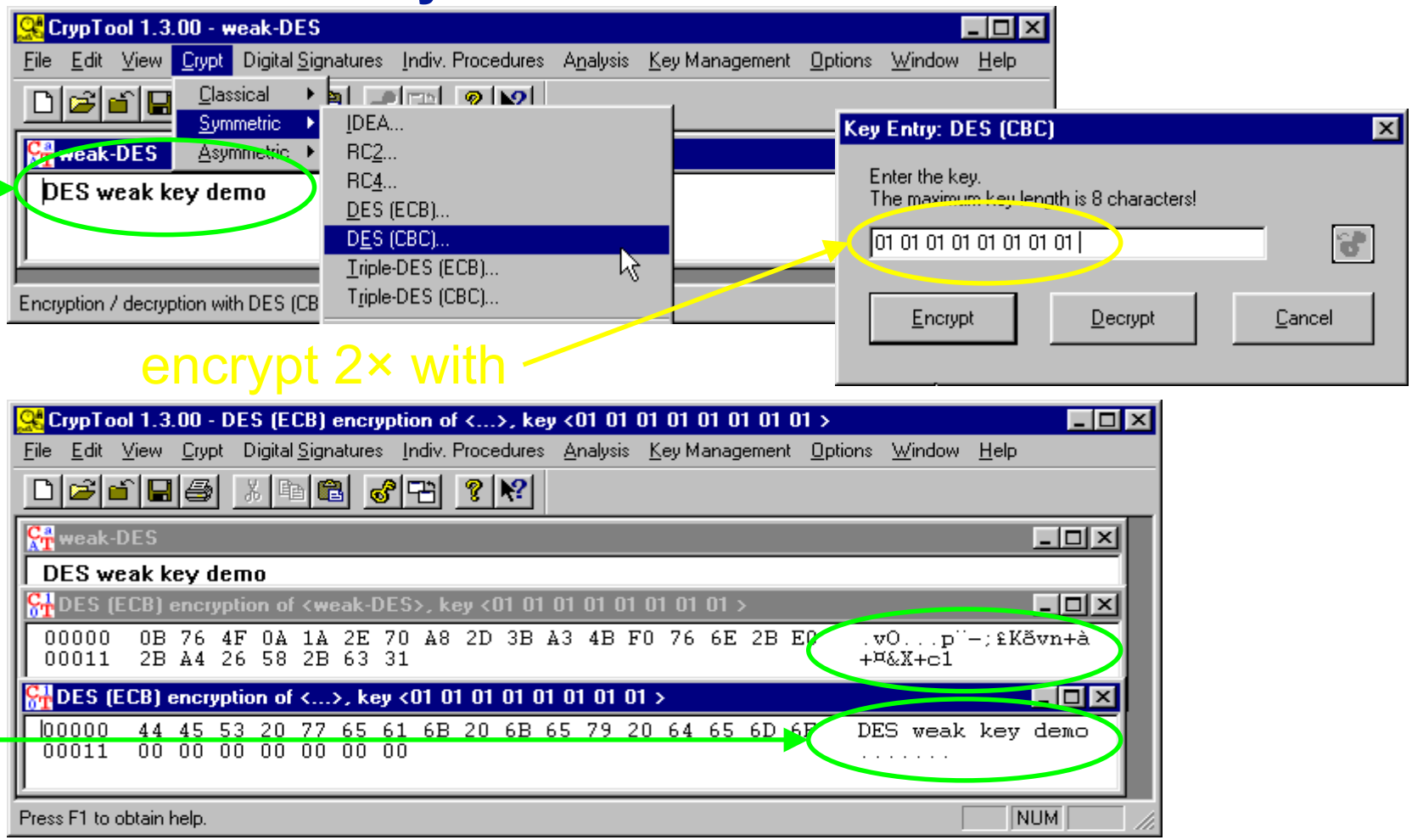
Examples of use
5. Weak DES keys



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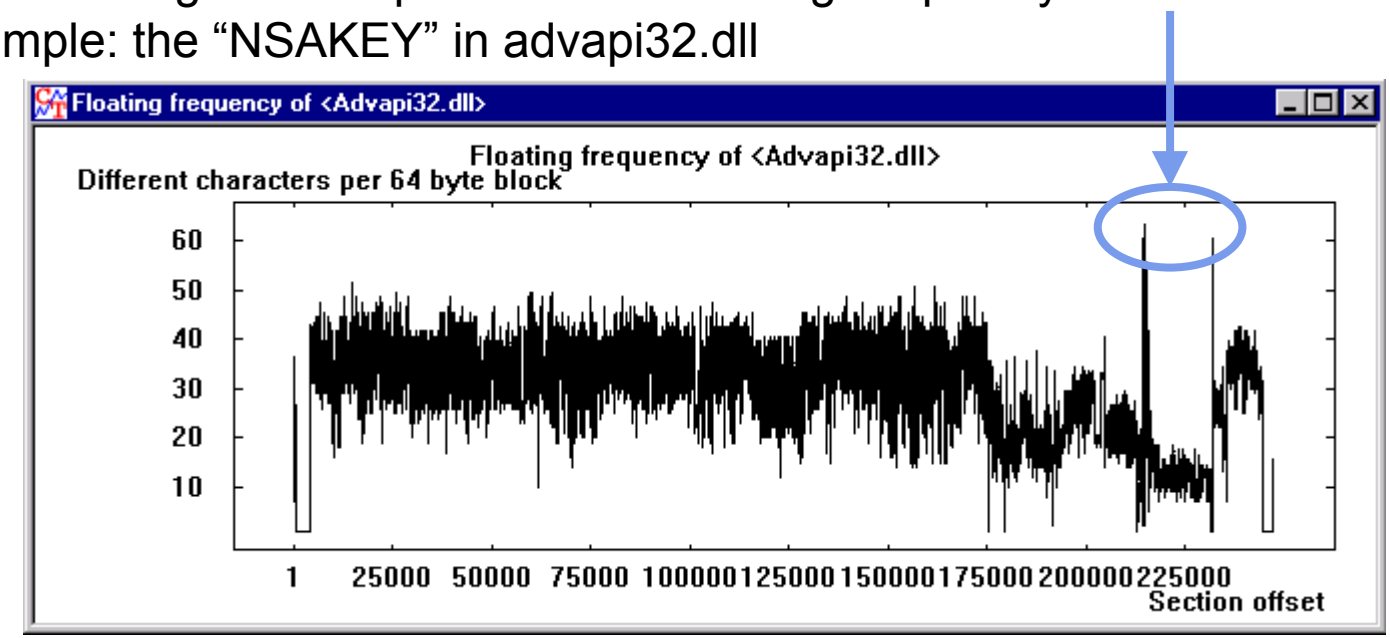
Examples of use
6. Locate key material

The function “Floating frequency” is suitable for locating key material and encrypted areas in files.

Background:

- key data is “more random” than text or program code
- can be recognised as peaks in the “floating frequency”
- example: the “NSAKEY” in advapi32.dll



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