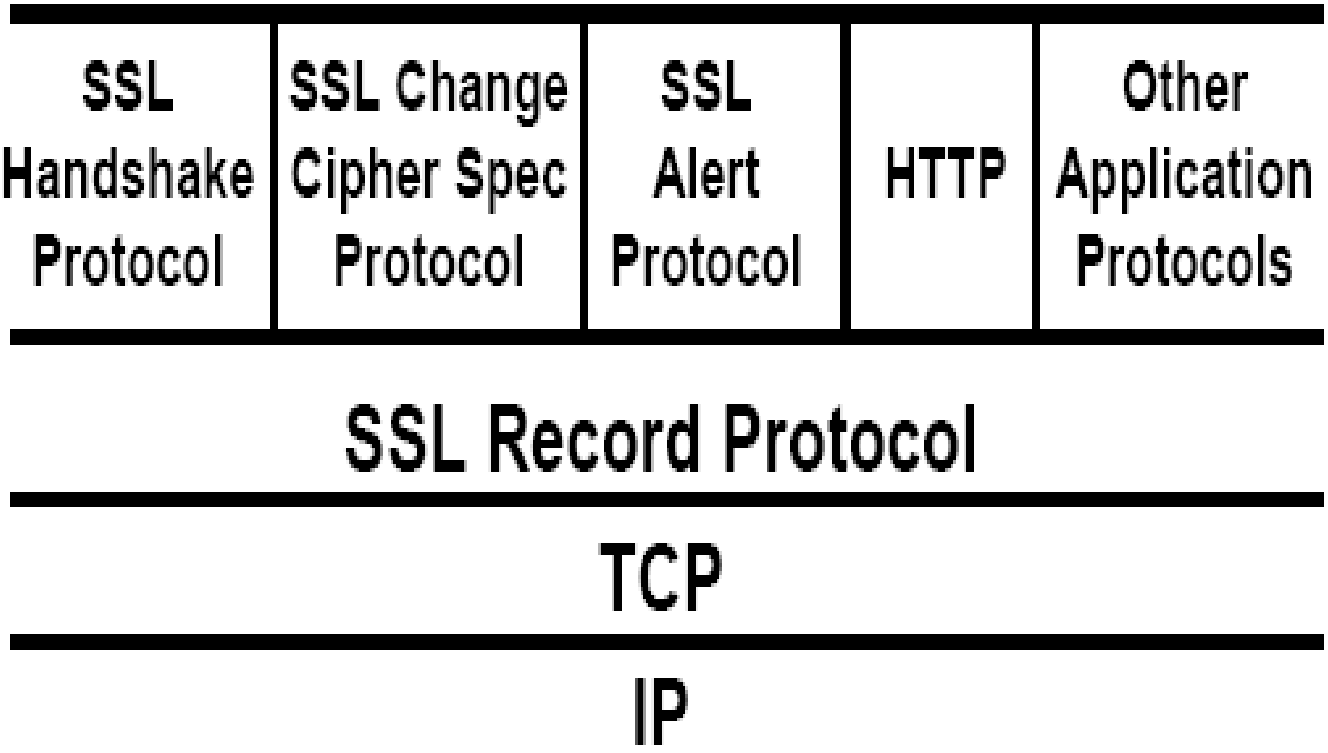
Secure Socket Layer

Position of SSL



SSL ARCHITECTURE(Cont..)

- **Handshake protocol:**
  - **Establish Security Capabilites**
  - **Server & Client Authentication and key exchange**
  - **10 message types**
- **Record protocol:**
  - **fragment, compress, MAC, encrypt**
- **Alert protocol: straightforward**
  - **2 byte messages**
  - **1 byte alert level - fatal or warning; 1 byte alert code**

SSL SERVICES

- **Peer entity authentication**
- **Data confidentiality**
- **Data authentication and integrity**
- **Compression/decompression**
- **Generation/distribution of session keys**
  - **integrated into protocol**
- **Security parameter negotiation**

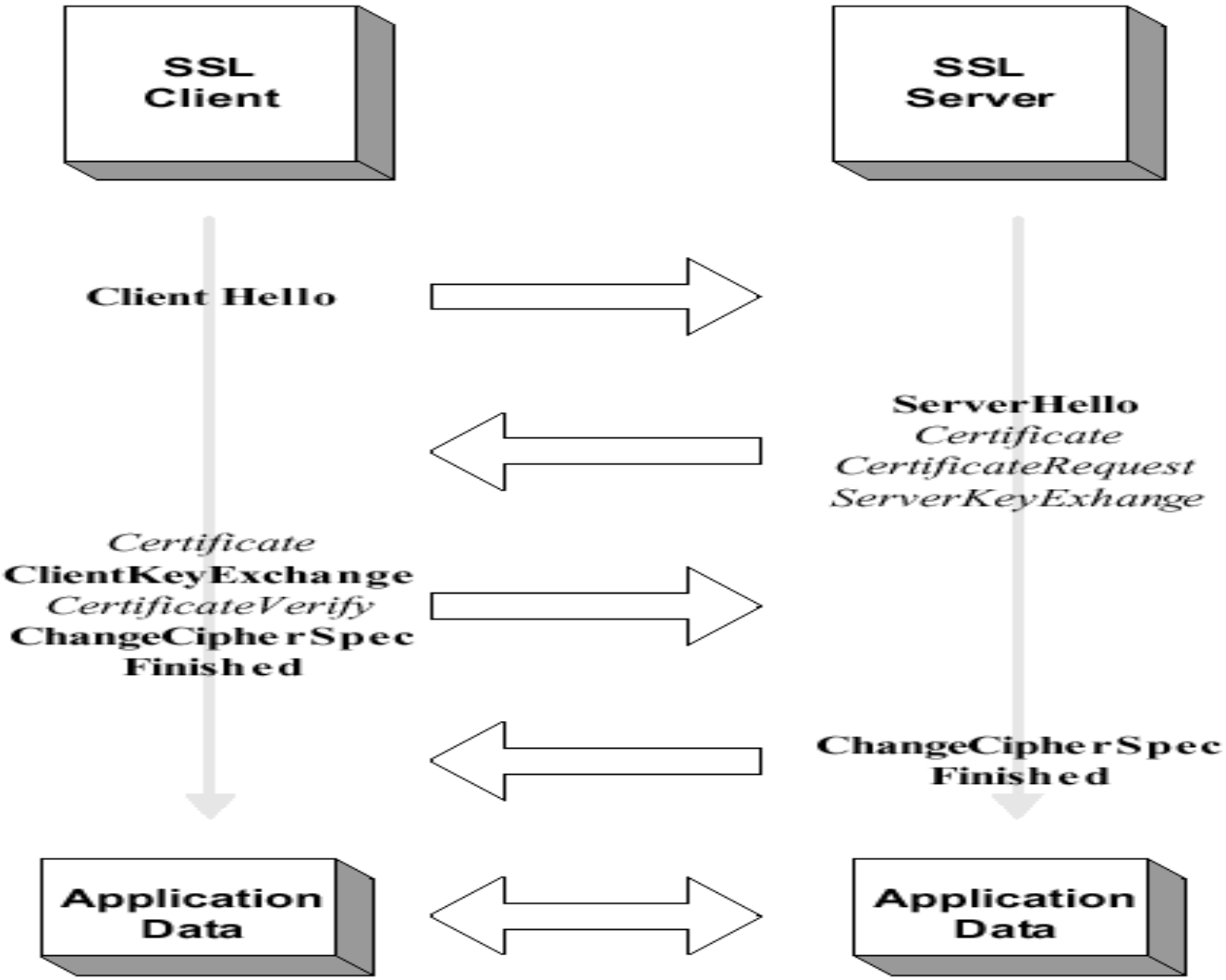
SSL HANDSHAKE PROTOCOL

- **Initially SSL session has null compression and cipher algorithms**
- **Both are set by the handshake protocol at beginning of session**
- **Handshake protocol may be repeated during the session**
- **Message Format**
  - **Type: 1 byte**
    - **10 message types defined**
  - **length: 3 bytes**
  - **content**

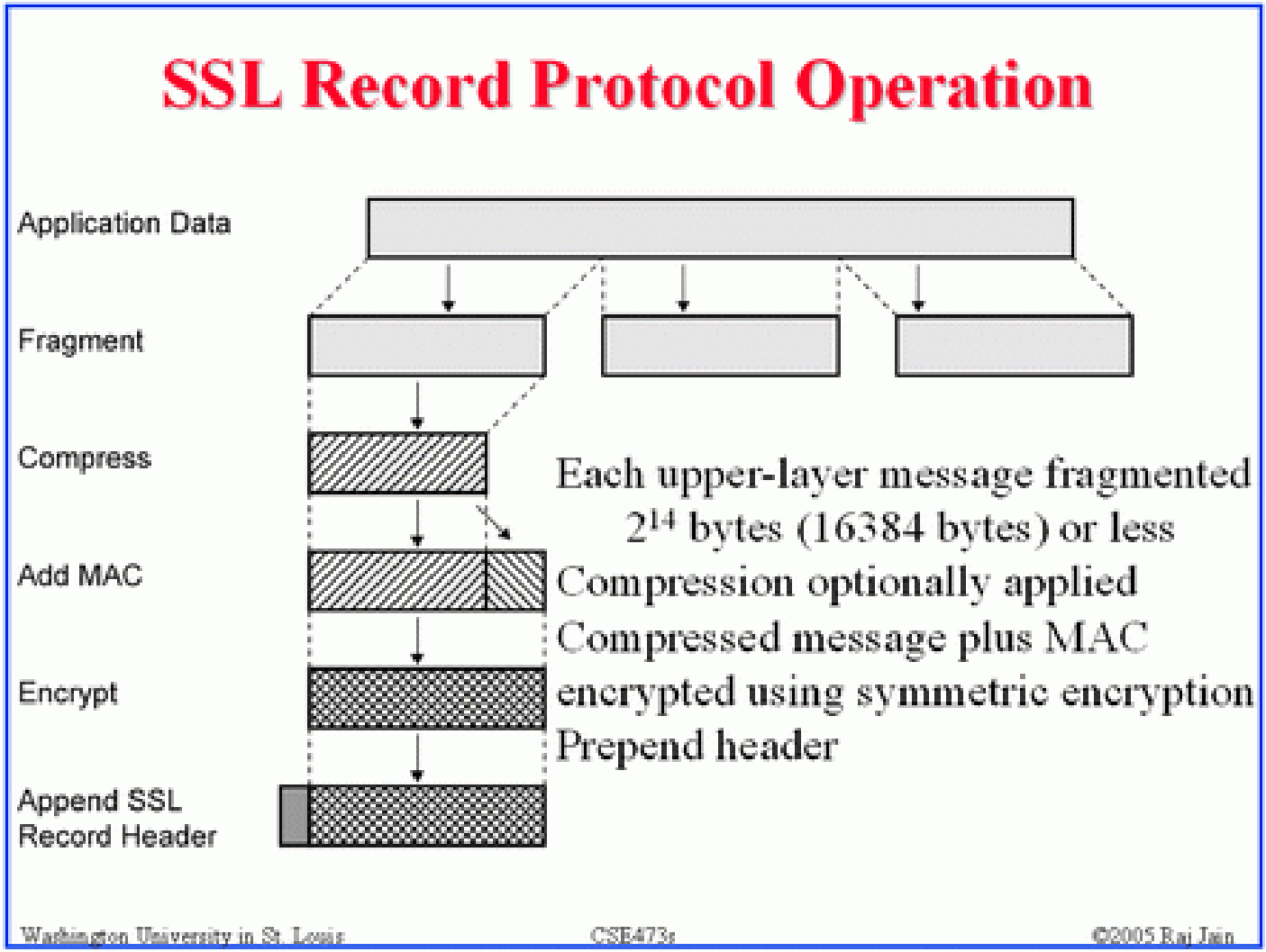
SSL HANDSHAKE PROTOCOL

- **Phase 1:**
  - **Establish security capabilities**
- **Phase 2:**
  - **Server authentication and key exchange**
- **Phase 3:**
  - **Client authentication and key exchange**
- **Phase 4:**
  - **Finish**

SSL HANDSHAKE PROTOCOL



SSL RECORD PROTOCOL



SSL RECORD PROTOCOL

- **each SSL record contains**
  - **content type: 8 bits, only 4 defined**
    - **change_cipher_spec**
    - **alert**
    - **handshake**
    - **application_data**
  - **protocol version number: 8 bits major, 8 bits minor**
  - **length: max 16K bytes (actually $2^{14} + 2048$)**
  - **data payload: optionally compressed and encrypted**
  - **message authentication code (MAC)**

SSL ALERT PROTOCOL

- **2 byte alert messages**
  - **1 byte level**
    - **fatal or warning**
  - **1 byte alert code**

SSL ALERT MESSAGES

- **Warning or fatal**
  - **close_notify(0),**
  - **unexpected_message(10),**
  - **bad_record_mac(20),**
  - **decryption_failed(21),**
  - **record_overflow(22),**
  - **decompression_failure(30),**
  - **handshake_failure(40),**
  - **bad_certificate(42),**
  - **unsupported_certificate(43),**
  - **certificate_revoked(44),**
  - **certificate_expired(45),**
  - **certificate_unknown(46),**
  - **illegal_parameter(47),**
  - **unknown_ca(48),**
  - **access_denied(49),**
  - **decode_error(50),**
  - **decrypt_error(51),**
  - **export_restriction(60),**
  - **protocol_version(70),**
  - **insufficient_security(71),**
  - **internal_error(80),**
  - **user_canceled(90),**
  - **no_renegotiation(100**

Electronic mail Security

Pretty Good Privacy (PGP)
&
S/MIME

There are two main schemes which are especially designed to provide confidentiality and authentication for electronic mail systems. These are:

PGP

(Pretty Good Privacy)

S/MIME

(Secure/Multipurpose Internet Mail Extension)

PGP

- Developed by Phil Zimmerman in 1995.
- Documentation and source code is freely available.
- The package is independent of operating system and processor.

PGP

- PGP assumes that all users are using public key cryptography and have generated a private/public key pair.
- Either RSA (with RSA digital signatures) or DSA
- All users also use a symmetric key system such as triple DES or Rijndael.

PGP services

- messages
  - authentication
  - confidentiality
  - compression
  - e-mail compatibility
  - segmentation and reassembly
- key management
  - generation, distribution, and revocation of public/private keys
  - generation and transport of session keys and IVs

PGP E-Mail Compatibility

Many electronic mail systems can only transmit blocks of ASCII text. This can cause a problem when sending encrypted data since ciphertext blocks might not correspond to ASCII characters which can be transmitted.

PGP overcomes this problem by using **radix-64 conversion**.

Radix-64 conversion

Suppose the text to be encrypted has been converted into binary using ASCII coding and encrypted to give a ciphertext stream of binary.

Radix-64 conversion maps arbitrary binary into printable characters as follows:

Radix-64 conversion

1. The binary input is split into blocks of 24 bits (3 bytes).
2. Each 24 block is then split into four sets each of 6-bits.
3. Each 6-bit set will then have a value between 0 and 2^6-1 (=63).
4. This value is encoded into a printable character.

6 bit value	Character encoding	6 bit value	Character encoding	6 bit value	Character encoding	6 bit value	Character encoding
0	A	16	Q	32	g	48	w
1	B	17	R	33	h	49	x
2	C	18	S	34	i	50	y
3	D	19	T	35	j	51	z
4	E	20	U	36	k	52	0
5	F	21	V	37	l	53	1
6	G	22	W	38	m	54	2
7	H	23	X	39	n	55	3
8	I	24	Y	40	o	56	4
9	J	25	Z	41	p	57	5
10	K	26	a	42	q	58	6
11	L	27	b	43	r	59	7
12	M	28	c	44	s	60	8
13	N	29	d	45	t	61	9
14	O	30	e	46	u	62	+
15	P	31	f	47	v	63	/
						(pad)	=

What is S/MIME?

- Secure / Multipurpose Internet Mail Extension
- a security enhancement to MIME
- provides similar services to PGP
- based on technology from RSA Security
- industry standard for commercial and organizational use
- RFC 2045 to 2049

RFC 822

- defines a format for text messages to be sent using e-mail
- Internet standard
- structure of RFC 822 compliant messages
  - header lines (e.g., from: …, to: …, cc: …)
  - blank line
  - body (the text to be sent)
- example

```
Date: Tue, 16 Jan 1998 10:37:17 (EST)
From: "Levente Buttyan" <buttyan@hit.bme.hu>
Subject: Test
To: afriend@otherhost.bme.hu
Blablabla
```

Problems with RFC 822 and SMTP

- executable files must be converted into ASCII
  - various schemes exist (e.g., Unix UUencode)
  - a standard is needed
- text data that includes special characters (e.g., Hungarian text)

- some servers
  - reject messages over a certain size
  - delete, add, or reorder CR and LF characters
  - truncate or wrap lines longer than 76 characters
  - remove trailing white space (tabs and spaces)
  - pad lines in a message to the same length
  - convert tab characters into multiple spaces

MIME

- defines new message header fields
- defines a number of content formats (standardizing representation of multimedia contents)
- defines transfer encodings that protects the content from alteration by the mail system

MIME - New header fields

- MIME-Version
- Content-Type
  - describes the data contained in the body
  - receiving agent can pick an appropriate method to represent the content
- Content-Transfer-Encoding
  - indicates the type of the transformation that has been used to represent the body of the message
- Content-ID
- Content-Description
  - description of the object in the body of the message
  - useful when content is not readable (e.g., audio data)

MIME – Content types and subtypes

- text/plain, text/enriched
- image/jpeg, image/gif
- video/mpeg
- audio/basic
- application/postscript, application/octet-stream
- multipart/mixed, multipart/parallel, multipart/alternative, multipart/digest (each part is message/rfc822)
- message/rfc822, message/partial, message/external-body

MIME – Transfer encodings

- 7bit - short lines of ASCII characters
- 8bit - short lines of non-ASCII characters
- binary
  - non-ASCII characters
  - lines are not necessarily short
- quoted-printable
  - non-ASCII characters are converted into hexa numbers (e.g., =EF)
- base64 (radix 64)
  - 3 8-bit blocks into 4 6-bit blocks

S/MIME services

- enveloped data (application/pkcs7-mime; smime-type = enveloped-data)
  - standard digital envelop
- signed data (application/pkcs7-mime; smime-type = signed-data)
  - standard digital signature (“hash and sign”)
  - content + signature is encoded using base64 encoding
- clear-signed data (multipart/signed)
  - standard digital signature
  - only the signature is encoded using base64
  - recipient without S/MIME capability can read the message but cannot verify the signature
- signed and enveloped data
  - signed and encrypted entities may be nested in any order

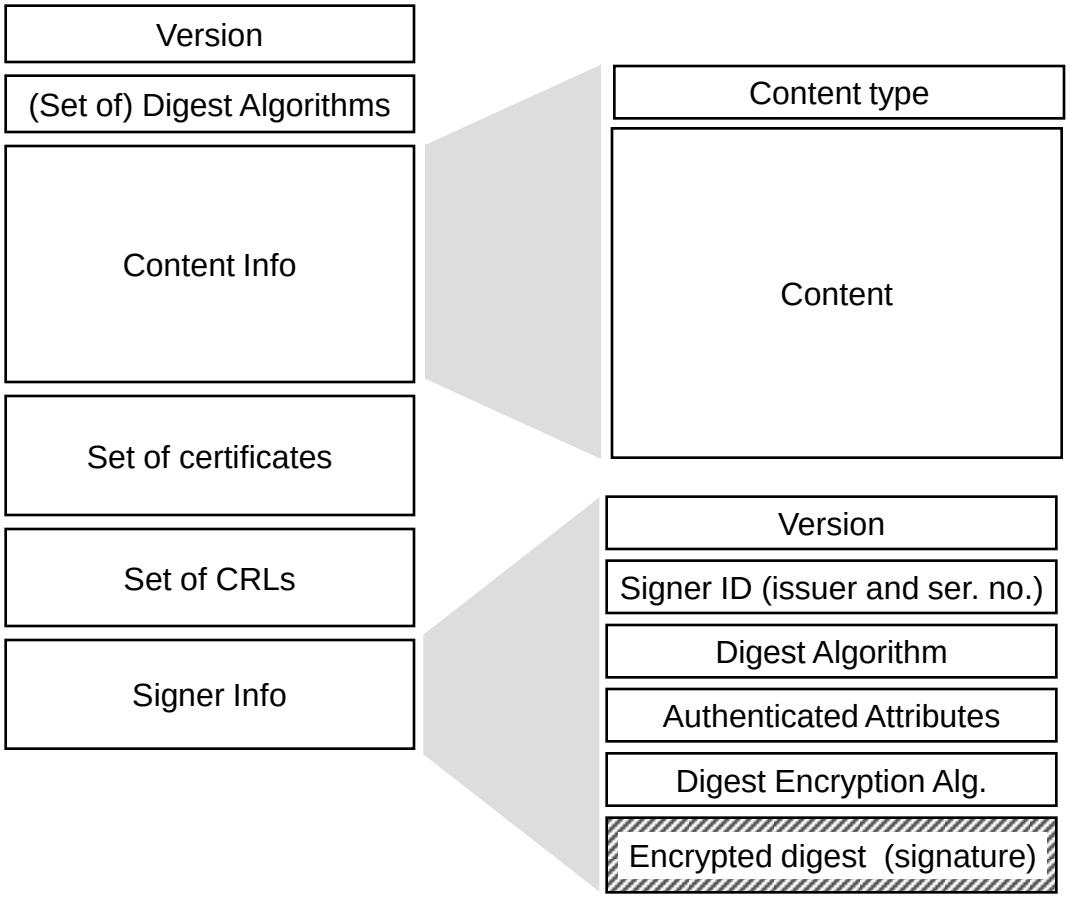
Cryptographic algorithms

- message digest
  - must: SHA-1
  - should (receiver): MD5 (backward compatibility)
- digital signature
  - must: DSS
  - should: RSA
- asymmetric-key encryption
  - must: ElGamal
  - should: RSA
- symmetric-key encryption
  - 3DES, RC2/40

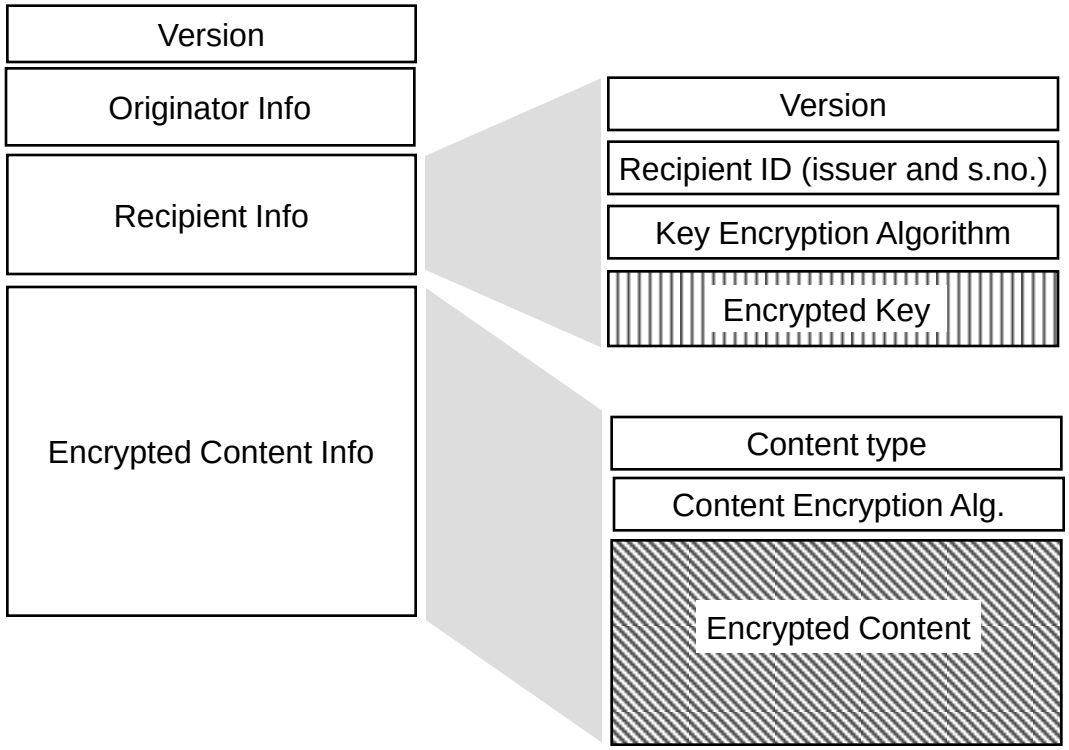
Securing a MIME entity

- MIME entity is prepared according to the normal rules for MIME message preparation
- prepared MIME entity is processed by S/MIME to produce a PKCS object
- the PKCS object is treated as message content and wrapped in MIME

PKCS7 “signed data”



PKCS7 “enveloped data”



Enveloped data – Example

Content-Type: application/pkcs7-mime; smime-type=enveloped-data; name=smime.p7m
Content-Transfer-Encoding: base64
Content-Disposition: attachment; filename=smime.p7m

rfvbnj756tbBghyHhHUujhJhjH77n8HHGT9HG4VQpfyF467GhIGfHfYT6
7n8HHGghyHhHUujhJh4VQpfyF467GhIGfHfYGTrfvbnjT6jH7756tbB9H
f8HHGTrfvhJhjH776tbB9HG4VQbnj7567GhIGfHfYT6ghyHhHUujpfyF4
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