Forenzika elektroničke pošte

Petar Djerasimović
Predrag Pale
Juraj Petrović

Elektronička pošta - e-mail

- **asinkrono** komuniciranje
- iznimno **učinkovit** za komunikacije jedan-na-više
- mehanizam **razmjene** za bilokakav tip podataka
- može se u potpunosti **automatizirati**

Forenzički interes?

- velika količina podataka:
  - informacije iz poruka
  - metapodaci iz poruka
    - kod primatelja, pošiljatelja i po putu

Sadržaj predavanja

- **Adresiranje** i **arhitektura**

- **Protokoli** koji se koriste

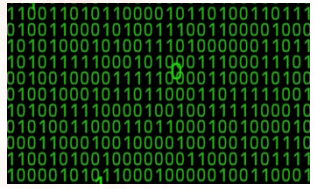
POP3
IMAP
MIME
SMTP

- **Zaglavlja** poruka

To:
From:
Date:
Received:
Subject:

- **Privitci**





- **Šifriranje**

Adresa elektroničke pošte

Oblik e-mail adrese

- oblik adrese je

primatelj@domena

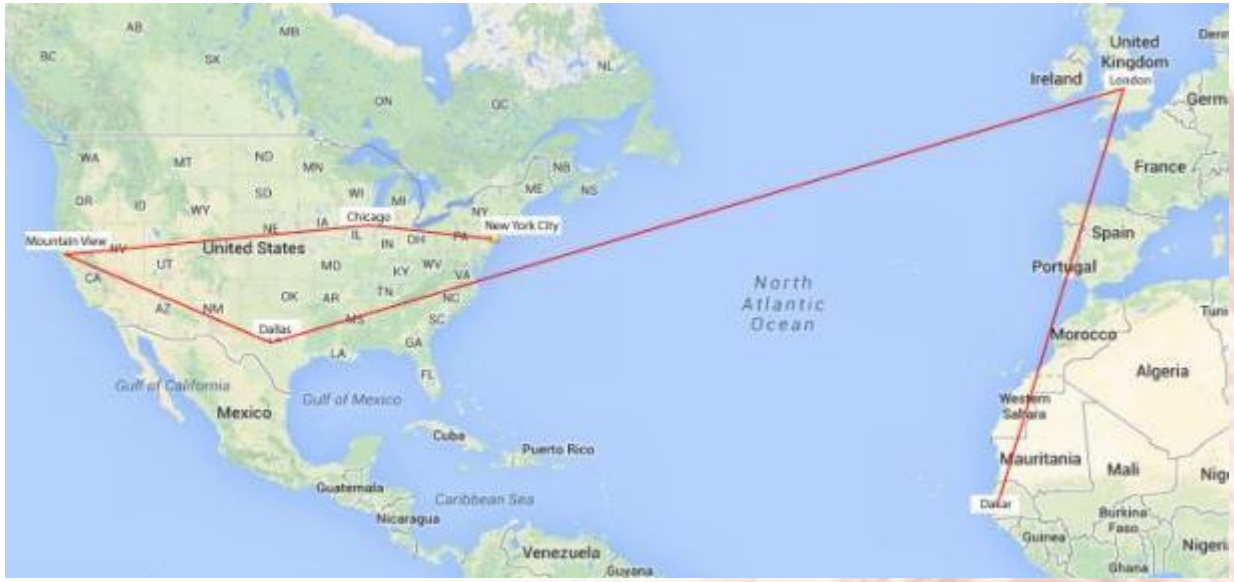
  - **primatelj** je
    - ili oznaka poštanskog sandučića: pperic12
    - ili ime osobe: Pero.Peric, PeroPeric, pero_peric
  - **domena** je adresa na kojoj se nalazi poštanski sandučić (*eng. mailbox*):
    - najčešće adresa **organizacije**: fer.hr
    - ili adresa **računala**: mailman.fer.hr

Podržani znakovi

- sustavi u praksi tipično ne razlikuju mala i velika slova

  Pero.Peric@FER.hr ≡ pero.peric@fer.hr

- dozvoljeni znakovi:
  - a-z A-Z 0-9 . _ - (dozvoljeni)
  - !#$%&'*+-/=?^`{|}~ (dozvoljeni, ali se ne preporučaju)
  - mogući su i dijakritički znakovi (ćčđšž) i drugi posebni znakovi, npr. संपर्क@डाटामेल.भारत
    - **još ih ne podržavaju svi** sustavi u svijetu



Kako e-mail poruke putuju

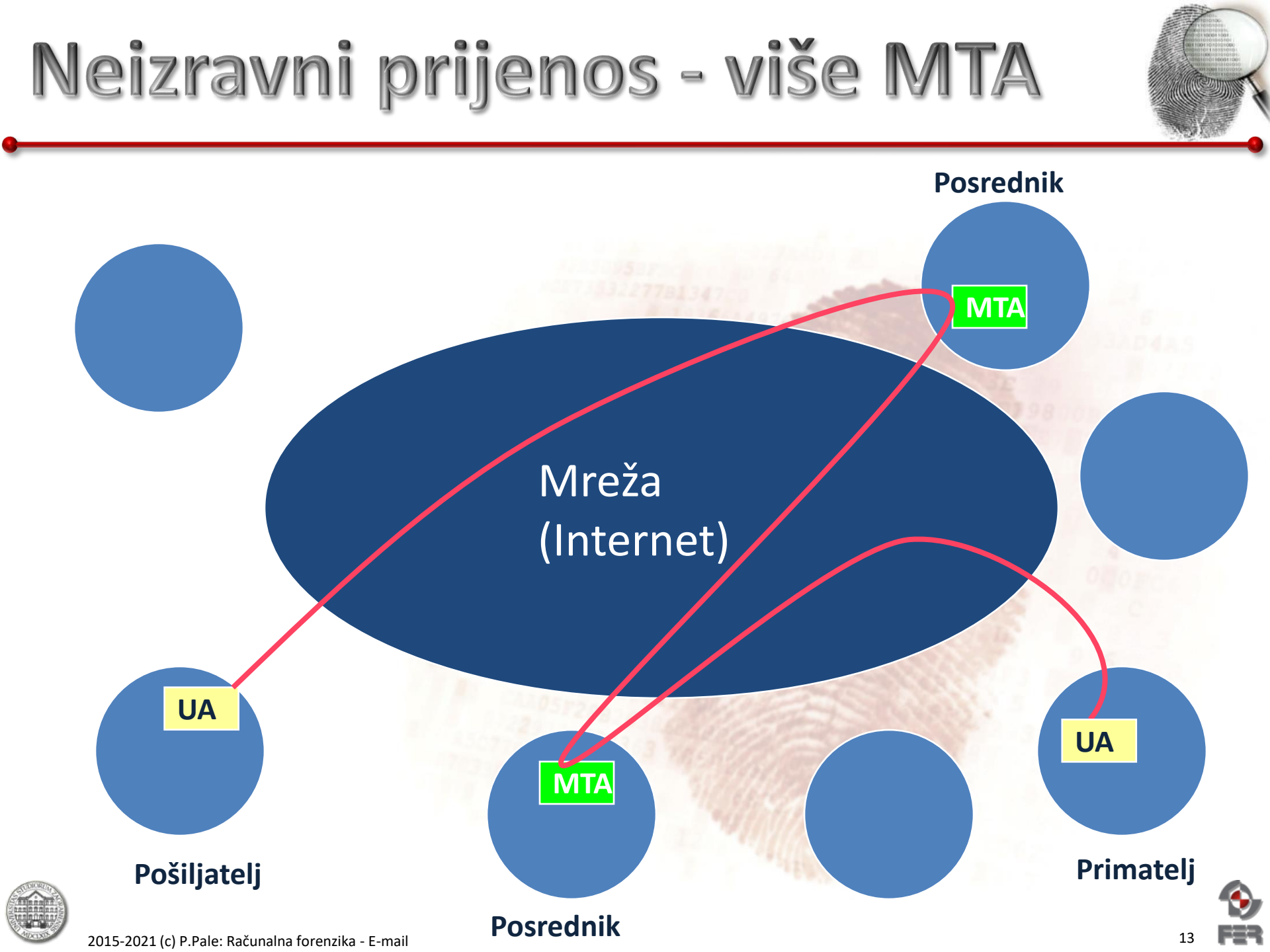
E-mail sustav - MUA

- message **user** agent (MUA) – "e-mail klijent"
  - **komunicira** s **korisnikom**
  - **komunicira** s **MTA**
    - kako bi **poslao** e-mail **primatelju**
    - **dohvaća primljene poruke** koje je primio i čuva MTA
  - popularni agenti:
    - mail, mailx, pine, elm, mutt
    - Outlook, Thunderbird, Eudora …
    - web based agents
      - Squirrel mail, RoundCube
      - Gmail, Yahoo, Hotmail

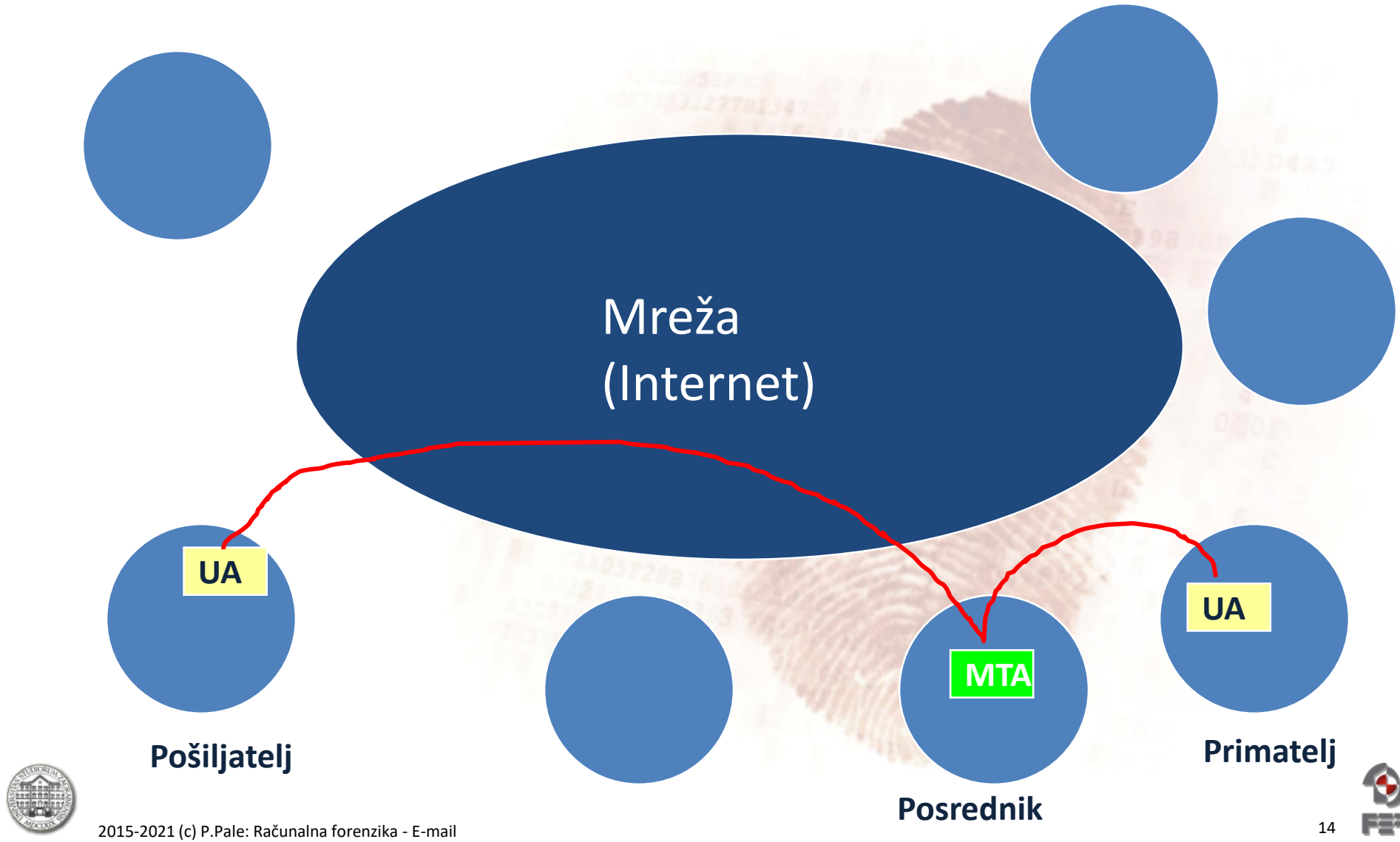

E-mail sustav - MTA

- message **transfer** agent (MTA)
  - mail transfer agent, mail relay
  - mail exchanger, mail server, MX host …
  - **on zapravo razmjenjuje poruke,** s drugim MTA
  - popularni MTA:
    - postfix, exim, sendmail
    - MS Exchange
    - IBM Domino (Lotus Notes)

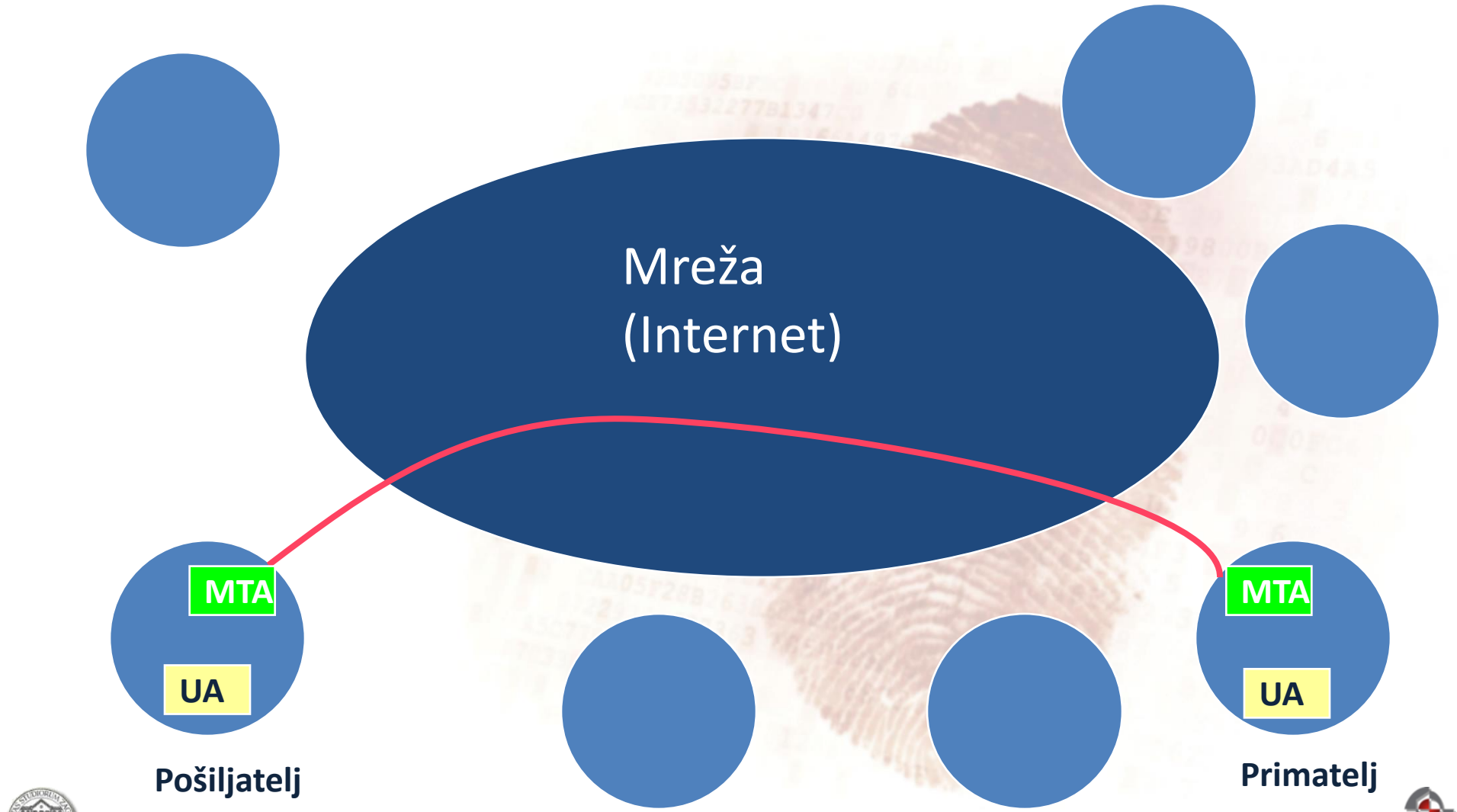
Neizravni prijenos - više MTA



Neizravni prijenos – jedan MTA

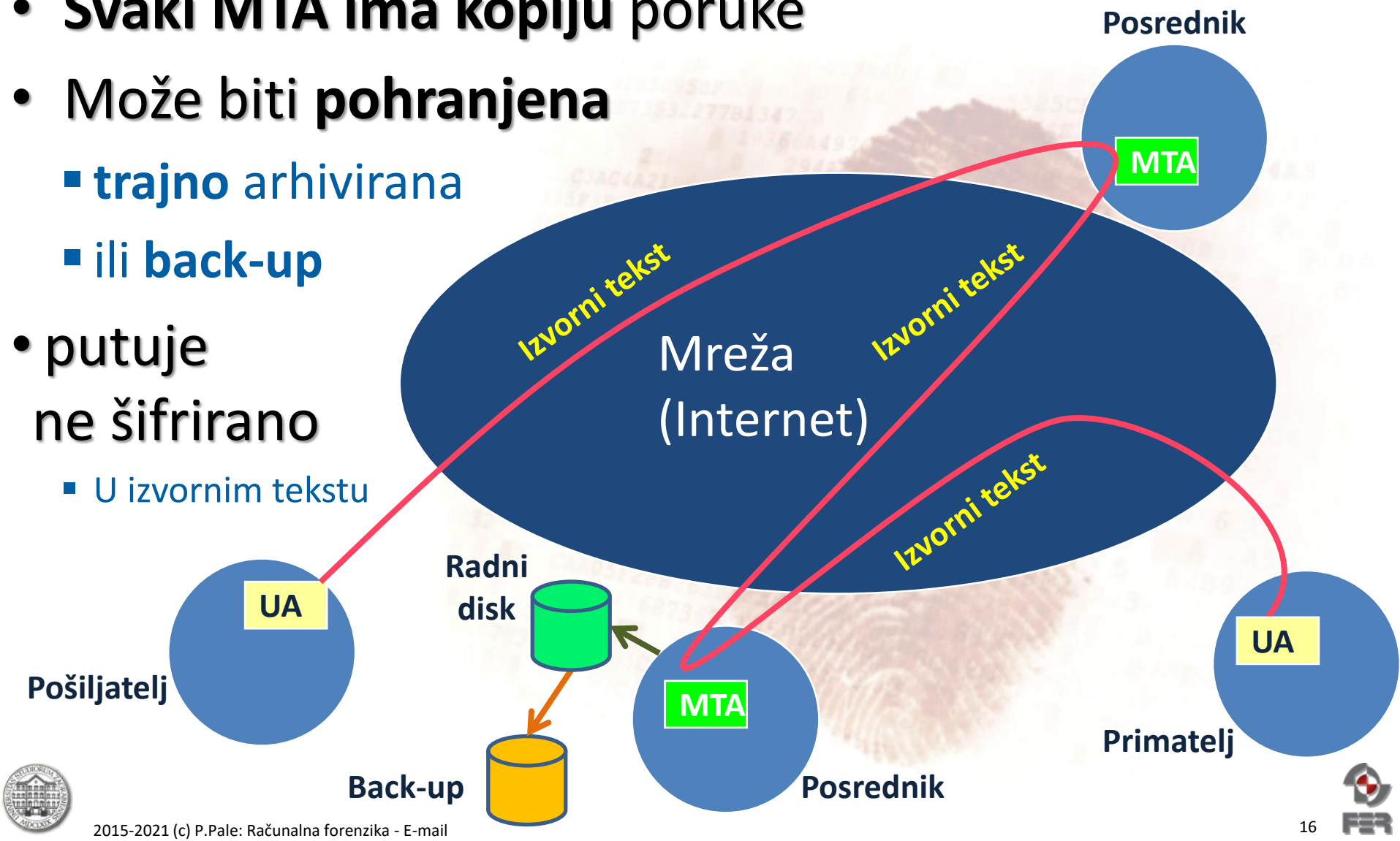


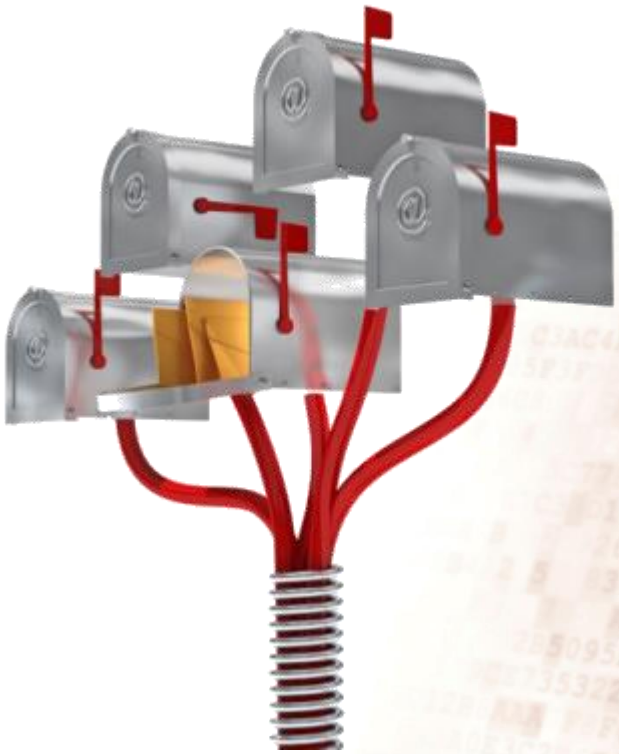
Peer—to—peer prijenos



Sigurnost prijenosa poruka

- **Svaki MTA ima kopiju** poruke
- Može biti **pohranjena**
  - **trajno** arhivirana
  - ili **back-up**
- putuje ne šifrirano
  - U izvornim tekstu

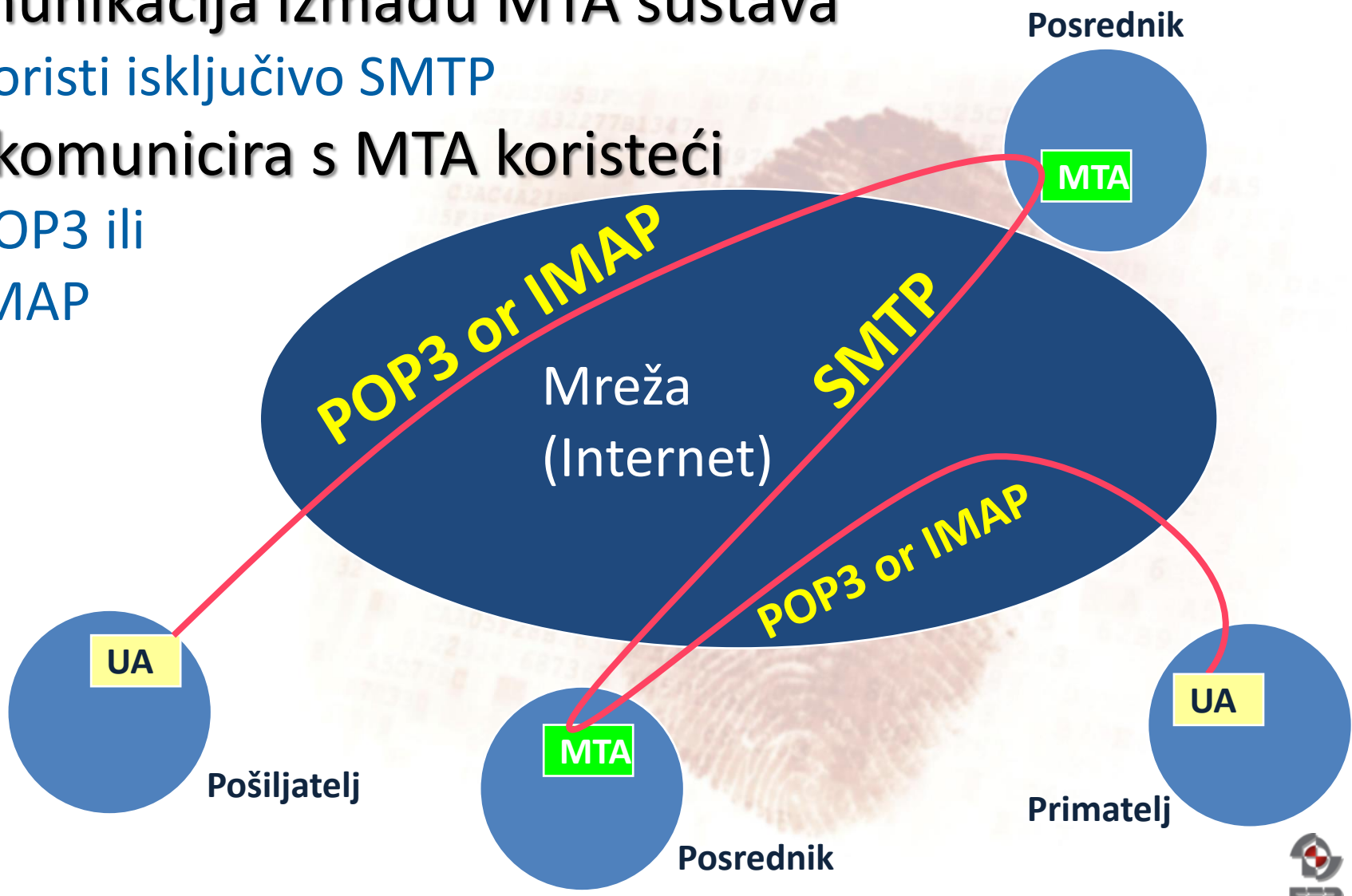




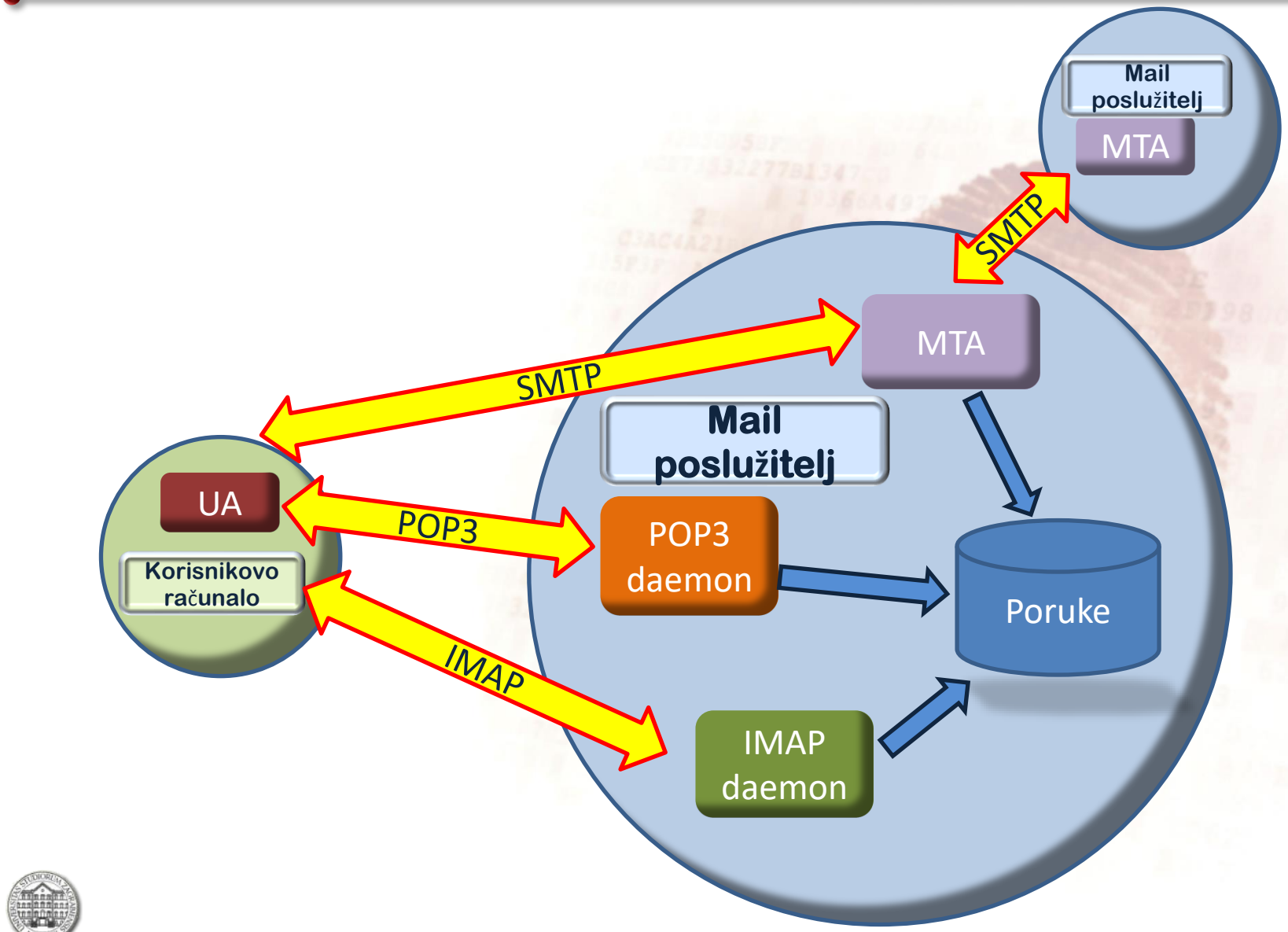
E-mail protokoli

Korištenje protokola za e-mail

- Komunikacija između MTA sustava
  - Koristi isključivo SMTP
- UA komunicira s MTA koristeći
  - POP3 ili
  - IMAP



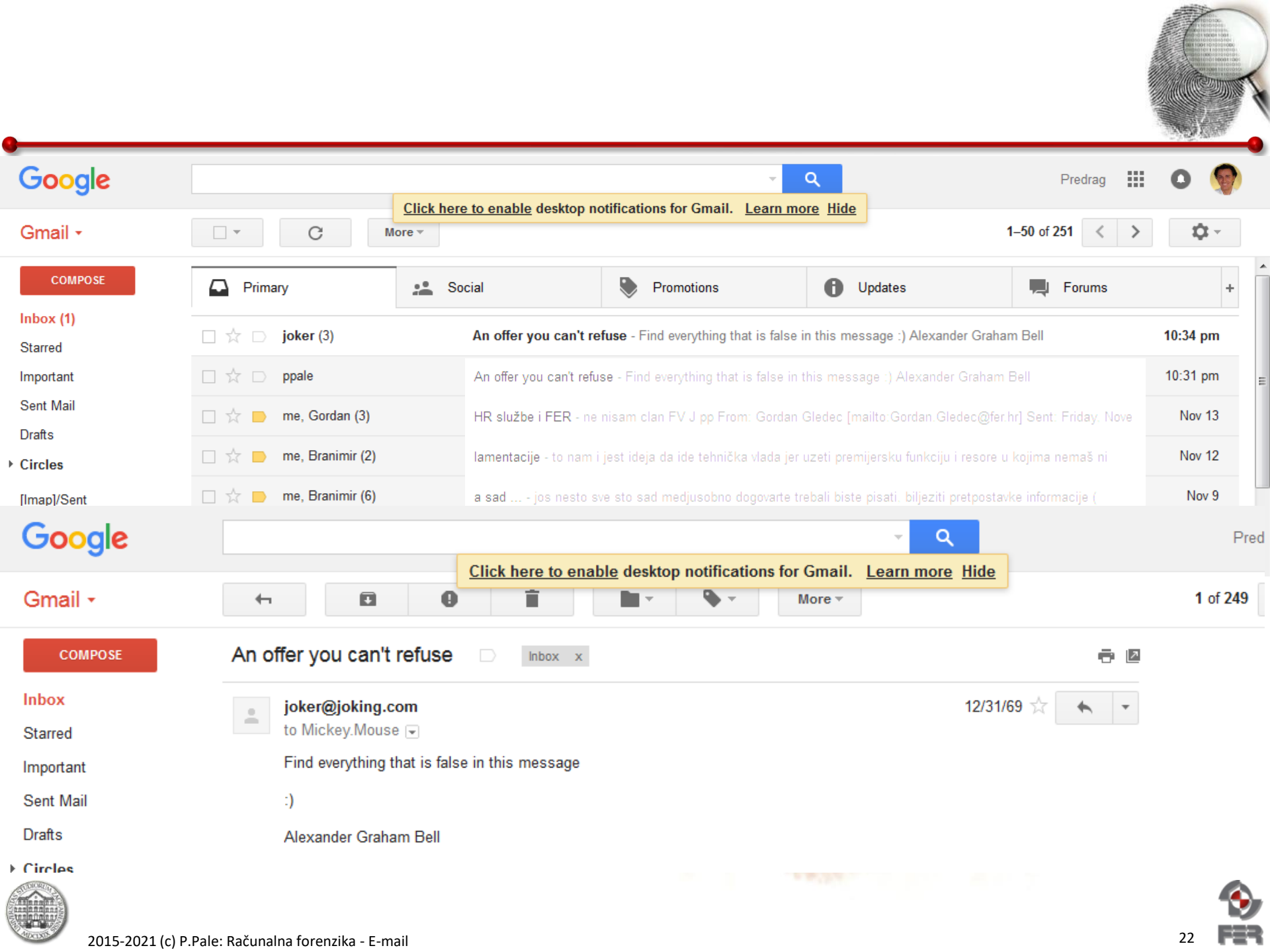
E-mail protokoli i korištenje



SMTP – Simple Mail Transfer Protocol

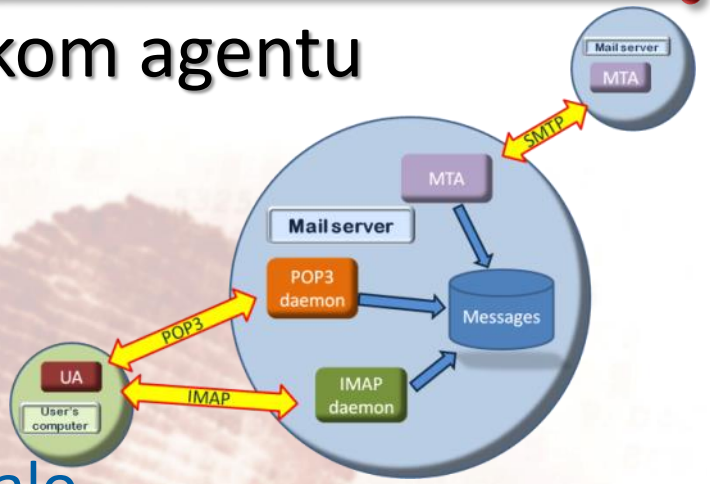
- MTA sustavi razmjenjuju poruke koristeći
  - Simple Mail Transfer Protocol
    - RFC 5321
      - ranije: 2821, 821
- Vrlo je star
  - i **zaista** vrlo jednostavan
    - **HELO** ana.zesoi.fer.hr
    - **MAIL FROM**: ppale
    - **RCPT TO**: comfor-test
    - **DATA**
    - Ovo je test poruka
    - .
    - **QUIT**
- Gotovo **ništa se ne provjerava**
  - **Sve** je moguće **krivotvoriti**

```
C:\Users\ppale>telnet maja.zesoi.fer.hr 25

220 maja.zesoi.fer.hr ESMTP Postfix
HELO pero
250 maja.zesoi.fer.hr
MAIL FROM: Albert.Zweistein@physics.world.org
250 2.1.0 Ok
RCPT TO: predrag.pale@gmail.com
250 2.1.0 Ok
DATA
354 End data with <CR><LF>.<CR><LF>
To: Mickey.Mouse@disneyland.org
From: joker@joking.com
Subject: An offer you can't refuse
Sender: Ms.Monneypenny@james.bond.com
Date: Thu, 21 May 2060 05:33:29 -0700

Find everything that is false in this message

:)

Alexander Graham Bell
.
250 2.0.0 Ok: queued as 6FF17B00A8
QUIT
221 2.0.0 Bye
```


Google
Predrag
Click here to enable desktop notifications for Gmail. Learn more Hide
Gmail
More
1–50 of 251
COMPOSE
Primary
Social
Promotions
Updates
Forums
Inbox (1)
Starred
Important
Sent Mail
Drafts
Circles
[Imap]/Sent
joker (3) An offer you can't refuse - Find everything that is false in this message :) Alexander Graham Bell 10:34 pm
ppale An offer you can't refuse - Find everything that is false in this message :) Alexander Graham Bell 10:31 pm
me, Gordan (3) HR službe i FER - ne nisam clan FV J pp From: Gordan Gledec [mailto:Gordan.Gledec@fer.hr] Sent: Friday, Nove Nov 13
me, Branimir (2) lamentacije - to nam i jest ideja da ide tehnička vlada jer uzeti premijersku funkciju i resore u kojima nemaš ni Nov 12
me, Branimir (6) a sad ... - jos nesto sve sto sad medjusobno dogovarte trebali biste pisati. biljeziti pretpostavke informacije (Nov 9
Google
Pred
Click here to enable desktop notifications for Gmail. Learn more Hide
Gmail
More
1 of 249
COMPOSE
An offer you can't refuse
Inbox x
Inbox
Starred
Important
Sent Mail
Drafts
Circles
joker@joking.com
to Mickey.Mouse
12/31/69
Find everything that is false in this message
:)
Alexander Graham Bell

Protokoli korisničkog agenta: POP3 & IMAP

- Protokoli koji omogućuju korisničkom agentu da pristupi porukama pohranjenim na MTA



- POP3 - Post Office Protocol
  - **Kopira poruke** na korisnikovo računalo
  - Stoga, pristup istom korisničkom računu s drugog računala
    - Neće pronaći poruke koje su već pročitane

- IMAP - Internet Message Access Protocol
  - **Ostavlja poruke** na poslužitelju (MTA)
  - Poruke se mogu organizirati u **direktorije**
  - Pogodno za **pristupanje porukama s više računala**

POP3

- Post Office Protocol inačica 3
  - **Kopira poruke** na korisnikovo računalo
  - Stoga, **pristup istom** korisničkom **računu s drugog računala**
    - **Neće pronaći poruke** koje su već pročitane
- **Vrlo jednostavan** protokol
  - **USER** john
  - **PASS** ******
  - **LIST**
  - **RETR** msg#
  - **DELE** msg#
  - **RSET**
  - **QUIT**

```
C:\Users\ppale>telnet maja.zesoi.fer.hr 110
+OK
USER john
+OK
PASS xyz123
+OK
LIST
1124 4229
1125 19662
1126 1200
1127 1060
1128 1691
.
RETR 1128
+OK
Return-Path: <Albert.Zweistein@physics.world.org>
Delivered-To: ppale@ppale.net
Received: from pero (dhcp-91.zesoi.fer.hr [161.53.64.91])
        by maja.zesoi.fer.hr (Postfix)
            with SMTP id 8CEBEB00BC
        for <ppale@ppale.net>;
            Sat, 14 Nov 2015 21:07:39 +0100 (CET)
To: mister.important@maja.zesoi.fer.hr
From: joker@joking.com
Subject: An offer you can't refuse
Sender: Ms.Monneypenny@maja.zesoi.fer.hr
Date: Middleday, 32 May 2060 05:33:29 -0700

Message-Id: <20151114200741.DEA58B00C2@maja.zesoi.fer.hr>
Status: RO

this is a test mesaege
end
.
QUIT
C:\Users\ppale>
```

Autentičnost sadržaja e-mail poruka

```
C:\Users\ppale>telnet maja.zesoi.fer.hr 25

220 maja.zesoi.fer.hr ESMTP Postfix
HELO pero
250 maja.zesoi.fer.hr
MAIL FROM: Albert.Zweistein@physics.world.org
250 2.1.0 Ok
RCPT TO: predrag.pale@gmail.com
250 2.1.0 Ok
DATA
354 End data with <CR><LF>.<CR><LF>
To: Mickey.Mouse@disneyland.org
From: joker@joking.com
Subject: An offer you can't refuse
Sender: Ms.Monneypenny@james.bond.com
Date: Thu, 21 May 2060 05:33:29 -0700

Find everything that is false in this message

:)

Alexander Graham Bell
.
250 2.0.0 Ok: queued as 6FF17B00A8
QUIT
221 2.0.0 Bye
```

Koliko je e-mail poruka autentična?

Google

Predrag

Click here to enable desktop notifications for Gmail. Learn more Hide

Gmail

More

1–50 of 251

COMPOSE

Primary | Social | Promotions | Updates | Forums

Inbox (1)
Starred
Important
Sent Mail
Drafts
Circles
[Imap]/Sent

joker (3)	**An offer you can't refuse** - Find everything that is false in this message :) Alexander Graham Bell	10:34 pm
ppale	An offer you can't refuse - Find everything that is false in this message :) Alexander Graham Bell	10:31 pm
me, Gordan (3)	HR službe i FER - ne nisam clan FV J pp From: Gordan Gledec [mailto:Gordan.Gledec@fer.hr] Sent: Friday, Nove	Nov 13
me, Branimir (2)	lamentacije - to nam i jest ideja da ide tehnička vlada jer uzeti premijersku funkciju i resore u kojima nemaš ni	Nov 12
me, Branimir (6)	a sad ... - jos nesto sve sto sad medjusobno dogovarte trebali biste pisati. biljeziti pretpostavke informacije (	Nov 9

Google

Pred

Click here to enable desktop notifications for Gmail. Learn more Hide

Gmail

More

1 of 249

COMPOSE

Inbox
Starred
Important
Sent Mail
Drafts
Circles

An offer you can't refuse

Inbox x

joker@joking.com
to Mickey.Mouse

12/31/69

Find everything that is false in this message

:)

Alexander Graham Bell

Pregled kroz drugi korisnički agent

Gordan Gledec RE: HR službe i PEK pet 13.11.2015 16:55 10 KB

Date: Today

joker@joking.c... An offer you can't refuse sub 14.11.2015 23:02 2 KB

An offer you can't refuse

Ms.Monneypenny@james.bond.com on behalf of joker@joking.com

Sent: pet 21.5.2060 14:33

To: Mickey.Mouse@disneyland.org

```
Find everything that is false in this message

:)

Alexander Graham Bell
```

An offer you can't refuse - Message (Plain Text)

Message | Developer | Add-Ins | Adobe PDF

Reply | Reply to All | Forward — Respond

Delete | Move to Folder | Create Rule | Other Actions — Actions

Block Sender | Safe Lists | Not Junk — Junk E-mail

Follow Up | Mark as Unread — Options

Find | Related | Select — Find

From: Ms.Monneypenny@james.bond.com on behalf of joker@joking.com

To: Mickey.Mouse@disneyland.org

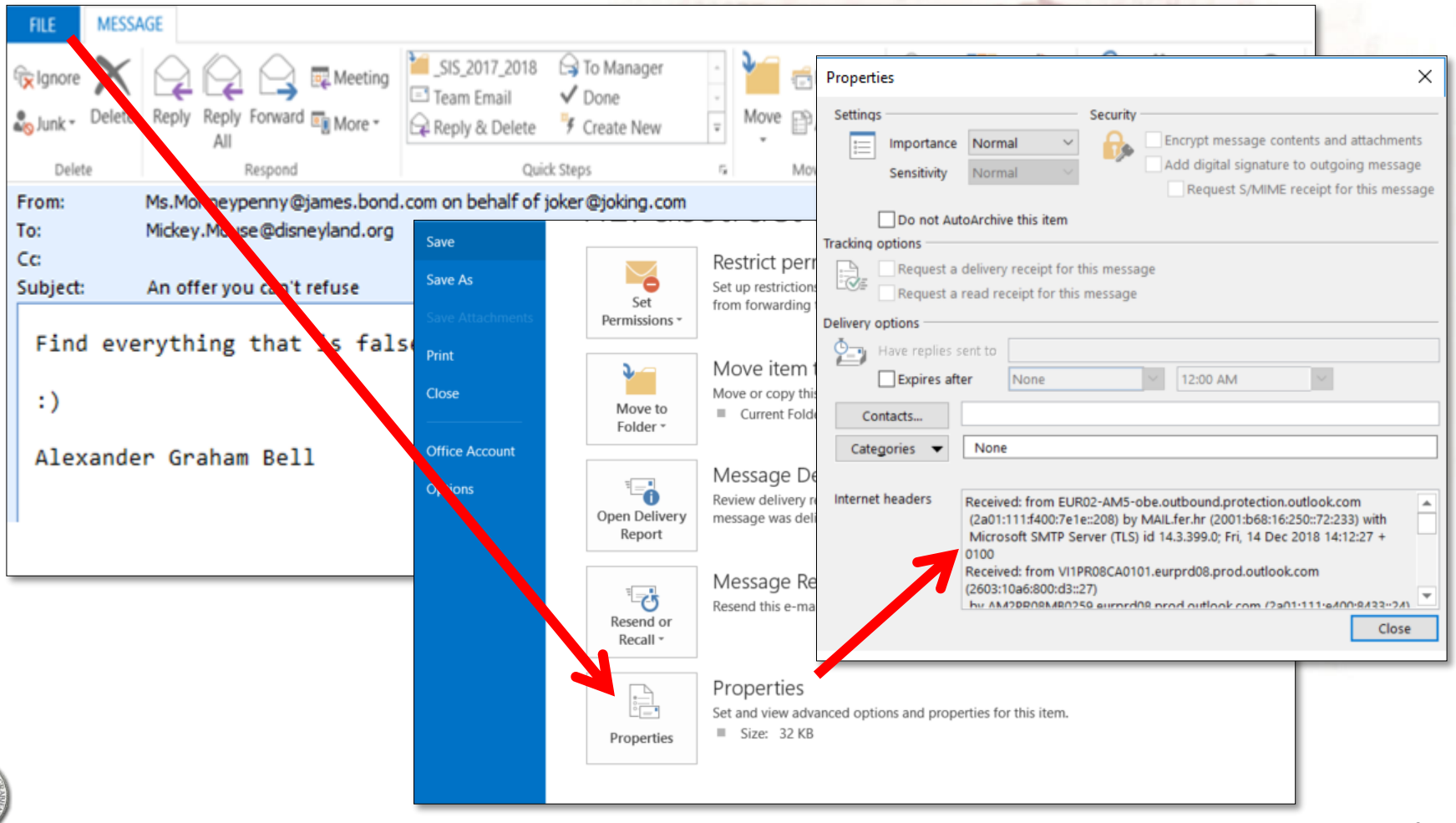
Cc:

Subject: An offer you can't refuse

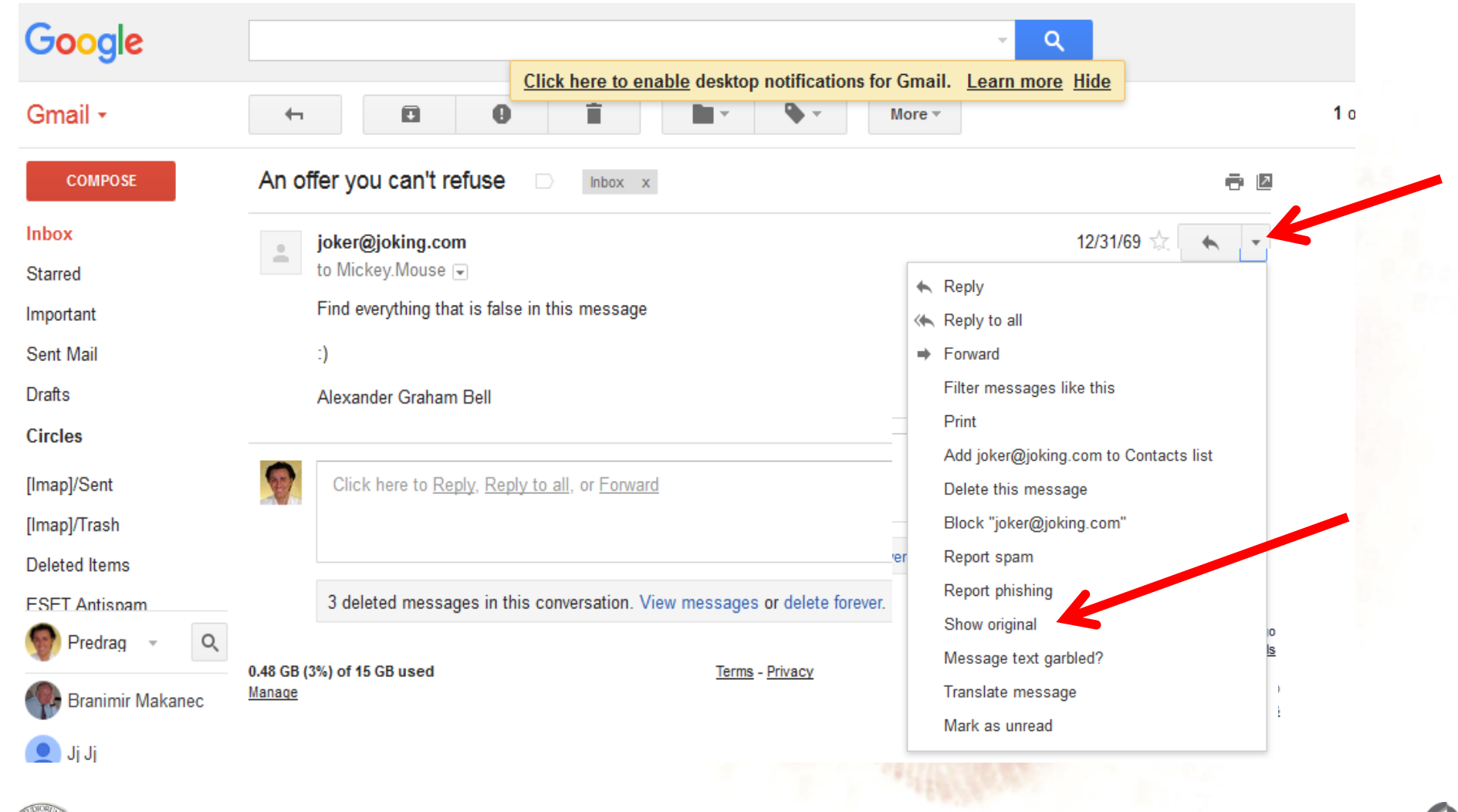
```
Find everything that is false in this message

:)

Alexander Graham Bell
```

Za forenziku su potrebna zaglavlja poruka

- Može se dobiti kod svakog korisničkog agenta
  - Na primjer u MS Outlook: ***File/Properties***



Ili, primjer u Gmail



Analiza e-mail zaglavlja

```
Delivered-To: predrag.pale@gmail.com
Received: by 10.64.56.166 with SMTP id b6csp1745238ieq; Sat, 14 Nov 2015
 13:34:29 -0800 (PST)
Return-Path: <Albert.Zweistein@physics.world.org>
Received: from maja.zesoi.fer.hr (maja.zesoi.fer.hr. [2001:b68:16:70::64:3])
 by mx.google.com with ESMTP id 200si15266292wmk.102.2015.11.14.13.34.29 for
 <predrag.pale@gmail.com>; Sat, 14 Nov 2015 13:34:29 -0800 (PST)
Received-SPF: neutral (google.com: 2001:b68:16:70::64:3 is neither permitted
 nor denied by best guess record for domain of
 Albert.Zweistein@physics.world.org) client-ip=2001:b68:16:70::64:3;
Received: from localhost (localhost [127.0.0.1]) by maja.zesoi.fer.hr
 (Postfix) with ESMTP id 80195B00C8 for <predrag.pale@gmail.com>; Sat, 14 Nov
 2015 22:33:37 +0100 (CET)
Received: from maja.zesoi.fer.hr ([127.0.0.1]) by localhost (maja.zesoi.fer.hr
 [127.0.0.1]) (amavisd-new, port 10024) with ESMTP id YsNLov-uYHD7 for
 <predrag.pale@gmail.com>; Sat, 14 Nov 2015 22:33:35 +0100 (CET)
Received: from pero (dhcp-91.zesoi.fer.hr [161.53.64.91]) by maja.zesoi.fer.hr
 (Postfix) with SMTP id CC2F0B00BC for <predrag.pale@gmail.com>; Sat, 14 Nov
 2015 22:33:35 +0100 (CET)
To: Mickey.Mouse@disneyland.org
From: joker@joking.com
Subject: An offer you can't refuse
Sender: Ms.Monneypenny@james.bond.com
Date: Thu, 21 May 2060 05:33:29 -0700
Message-Id: <20151114213337.80195B00C8@maja.z
```

?!

Tražiti prvi zapis (najniži na popisu) "Received:" liniju za **STVARNOG** pošiljatelja

e-mail zaglavlje - received

- (gotovo) svaka *received* stavka:
  - koji MTA je primio poruku u prijenosu
    - **`by mx.google.com`**
  - od koga ju je primio
    - **`from maja.zesoi.fer.hr (maja.zesoi.fer.hr. [2001:b68:16:70::64:3])`**
  - kada ju je primio
    - **`Sat, 14 Nov 2015 13:34:29 -0800 (PST)`**
  - koju oznaku joj je dodijelio u obradi
    - **`ESMTP id 200si15266292wmk.102.2015.11.14.13.34.29`**

…

Received: *from* ***maja.zesoi.fer.hr (maja.zesoi.fer.hr. [2001:b68:16:70::64:3])***
by ***mx.google.com*** *with* ***ESMTP id 200si15266292wmk.102.2015.11.14.13.34.29*** *for*
<predrag.pale@gmail.com>; ***Sat, 14 Nov 2015 13:34:29 -0800 (PST)***

…

Analiza e-mail zaglavlja

```
Delivered-To: predrag.pale@gmail.com
Received: by 10.64.56.166 with SMTP id b6csp1745238ieq; Sat, 14 Nov 2015
 13:34:29 -0800 (PST)
Return-Path: <Albert.Zweistein@physics.world.org>
Received: from maja.zesoi.fer.hr (maja.zesoi.fer.hr. [2001:b68:16:70::64:3])
 by mx.google.com with ESMTP id 200si15266292wmk.102.2015.11.14.13.34.29 for
 <predrag.pale@gmail.com>; Sat, 14 Nov 2015 13:34:29 -0800 (PST)
Received-SPF: neutral (google.com: 2001:b68:16:70::64:3 is neither permitted
 nor denied by best guess record for domain of
 Albert.Zweistein@physics.world.org) client-ip=2001:b68:16:70::64:3;
Received: from localhost (localhost [127.0.0.1]) by maja.zesoi.fer.hr
 (Postfix) with ESMTP id 80195B00C8 for <predrag.pale@gmail.com>; Sat, 14 Nov
 2015 22:33:37 +0100 (CET)
Received: from maja.zesoi.fer.hr ([127.0.0.1]) by localhost (maja.zesoi.fer.hr
 [127.0.0.1]) (amavisd-new, port 10024) with ESMTP id YsNLov-uYHD7 for
 <predrag.pale@gmail.com>; Sat, 14 Nov 2015 22:33:35 +0100 (CET)
Received: from pero (dhcp-91.zesoi.fer.hr [161.53.64.91]) by maja.zesoi.fer.hr
 (Postfix) with SMTP id CC2F0B00BC for <predrag.pale@gmail.com>; Sat, 14 Nov
 2015 22:33:35 +0100 (CET)
To: Mickey.Mouse@disneyland.org
From: joker@joking.com
Subject: An offer you can't refuse
Sender: Ms.Monneypenny@james.bond.com
Date: Thu, 21 May 2060 05:33:29 -0700
Message-Id: <20151114213337.80195B00C8@maja.zesoi.fer.hr>
```

Je li poruka autentična?

- je li poruka NEautentična?
  - kako izgleda izvornik poruke?
  - sastavite kronologiju slanja
    (pazite na razliku u vremenskoj zoni MTA)
  - odgovaraju li (E)SMTP id vremenima?
  - postoje li na MTA tragovi poruke?
- postoji li IP adresa pošiljatelja?

Primjer 1 – autentičnost (1/2)

Security Alert. You account has been hacked. Password [redacted] must be need changed.

J juraj.petrovic@fer.hr
Thu 11/8/2018 11:10 AM
Juraj Petrović

I'm a programmer who cracked your email account and device about half year ago. You entered a password on one of the insecure site you visited, and I catched it. Your password from juraj.petrovic@fer.hr on moment of crack: **[password]**

Of course you can will change your password, or already made it. But it doesn't matter, my rat software update it every time. Please don't try to contact me or find me, it is impossible, since **I sent you an email from your email account**.

Through your e-mail, I uploaded malicious code to your Operation System. … I installed a rat software on your device and long tome spying for you.

…

I will not do this if you pay me a little amount. I think $867 is a nice price for it! I accept only Bitcoins. My BTC wallet: 1PcFYw7PQKUnj6RxqVwZ4TFuwWUPTyECKQ

…

Primjer 1 – autentičnost (2/2)

Received: from EUR01-HE1-obe.outbound.protection.outlook.com (2a01:111:f400:7e1f::203) by MAIL.fer.hr (2001:b68:16:250::72:233) with MS SMTP Server (TLS) id 14.3.399.0; Thu, 8 Nov 2018 11:10:03 +0100

Received: from DB6PR0802CA0028.eurprd08.prod.outlook.com (2603:10a6:4:a3::14) by HE1PR08MB0297.eurprd08.prod.outlook.com (2a01:111:e400:509d::26) with Microsoft SMTP Server (version=TLS1_2, cipher=TLS_ECDHE_RSA_WITH_AES_256_GCM_SHA384) id 15.20.1294.26; Thu, 8 Nov 2018 10:10:01 +0000

Received: from HE1EUR02FT044.eop-EUR02.prod.protection.outlook.com (2a01:111:f400:7e05::205) by DB6PR0802CA0028.outlook.office365.com (2603:10a6:4:a3::14) with Microsoft SMTP Server (version=TLS1_2, cipher=…SHA384) id 15.20.1294.21 via Frontend Transp; Thu, 8 Nov 2018 10:10:01 +0000 Authentication-Results: spf=none (sender IP is 5.89.187.149) smtp.mailfrom=fer.hr; fer.hr; dkim=none (message not signed) header.d=none;fer.hr; dmarc=none action=none header.from=fer.hr; Received-SPF: None (protection.outlook.com: fer.hr does not designate permitted sender hosts)

Received: from net-5-89-187-149.cust.vodafonedsl.it (5.89.187.149) by HE1EUR02FT044.mail.protection.outlook.com (10.152.11.75) with Microsoft SMTP Server id 15.20.1339.10 via Frontend Transport; Thu, 8 Nov 2018 10:09:58 +0000 Message-ID:093…0703A40D0934@IKDLF6A

From: juraj.petrovic@fer.hr
To: juraj.petrovic@fer.hr
Subject: Security Alert. You account has been hacked. Password **<password>** must be need changed.
Date: Thu, 8 Nov 2018 10:50:58 +0000

Primjer 2 - autentičnost

- Scenarij: X, zaposlenik firme *A Inc.* za loš poslovni potez želi okriviti Y, zaposlenika firme *B Inc.* X je sastavio poruku elektroničke pošte za koju će lažno ustvrditi da ju poslao Y.
  Pretpostavite da X ima puni pristup SMTP serveru *A Inc.*, ali da nema pristup SMTP serveru *B Inc*.

- Koje informacije treba X kako bi što uvjerljivije namjestio takav scenarij? Kako može doći do njih? Na koje ga načine forenzičar postupka i dalje može pokušati demantirati?

Pronalaženje i obrada poruka

- tragovi email poruka ovise o protokolu i klijentu
  - POP3 – poruke se tipično brišu sa servera
  - IMAP – poruke se čuvaju na serveru
  - webmail klijenti
    - malo tragova lokalno i teško ih je naći
  - dekstop klijenti
    - Outlook .pst datoteka
      - brisane poruke su u *deleted items*
      - *permanently deleted items* se ponekad isto mogu vratiti
- kada su prikupljene, pretraga po ključnim riječima
  - ***Yes, Donald Trump, the FBI Can Vet 650,000 Emails in Eight Days (2016)***

Format poruke

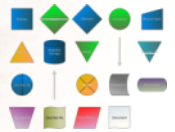
Format poruke

- Opisan u RFC 5322
  - ranije: 2822, 822

To:	Primaoc poruke
Cc:	Ostali primaoci (kopije poruke)
Bcc:	Ostali, “nevidljivi” primaoci (kopije poruke)
From:	Tko je pripremio poruku – autor
Sender:	Stvarni pošiljatlej poruke
Received:	Dodaje svaki MTA
Date:	Datum kada je poruka poslana
Message-Id:	Jedinstveni identifikator poruke
Subject:	Tema/naslov poruke

Potreba za privitcima

- **Osim tekstualnih** poruka
- **Imamo potrebu** razmjenjivati **ĆČĐŠŽčćđšž**
  - Tekst u **različitim jezicima** – koristeći posebne znakove
  - **formatirani** *tekst* **ĂĒŐŒŘąėğŋ**
- **Također trebamo** uključiti i poruku
  - fotografije, crteže, grafove, …
  - audio and video
  - Binarni sadržaj, programe, …



Postoji problem ...

- SMTP i MTA sustavi **napravljeni prije mnogo vremena**
  - kada **nije bilo**
    - digitalnih fotografija, grafova, audio i video sadržaja
  - i samo **za engleski jezik**
    - koristeći **samo 7 bitno** ASCII kodiranje znakova
  - nisu *8-bit clean*

0101 0001

ASCII tablica - 7 bita

Dec	Hx	Oct	Char	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr
0	0	000	NUL (null)	32	20	040		Space	64	40	100	@	@	96	60	140	`	`
1	1	001	SOH (start of heading)	33	21	041	!	!	65	41	101	A	A	97	61	141	a	a
2	2	002	STX (start of text)	34	22	042	"	"	66	42	102	B	B	98	62	142	b	b
3	3	003	ETX (end of text)	35	23	043	#	#	67	43	103	C	C	99	63	143	c	c
4	4	004	EOT (end of transmission)	36	24	044	$	$	68	44	104	D	D	100	64	144	d	d
5	5	005	ENQ (enquiry)	37	25	045	%	%	69	45	105	E	E	101	65	145	e	e
6	6	006	ACK (acknowledge)	38	26	046	&	&	70	46	106	F	F	102	66	146	f	f
7	7	007	BEL (bell)	39	27	047	'	'	71	47	107	G	G	103	67	147	g	g
8	8	010	BS (backspace)	40	28	050	(	(	72	48	110	H	H	104	68	150	h	h
9	9	011	TAB (horizontal tab)	41	29	051	)	)	73	49	111	I	I	105	69	151	i	i
10	A	012	LF (NL line feed, new line)	42	2A	052	*	*	74	4A	112	J	J	106	6A	152	j	j
11	B	013	VT (vertical tab)	43	2B	053	+	+	75	4B	113	K	K	107	6B	153	k	k
12	C	014	FF (NP form feed, new page)	44	2C	054	,	,	76	4C	114	L	L	108	6C	154	l	l
13	D	015	CR (carriage return)	45	2D	055	-	-	77	4D	115	M	M	109	6D	155	m	m
14	E	016	SO (shift out)	46	2E	056	.	.	78	4E	116	N	N	110	6E	156	n	n
15	F	017	SI (shift in)	47	2F	057	/	/	79	4F	117	O	O	111	6F	157	o	o
16	10	020	DLE (data link escape)	48	30	060	0	0	80	50	120	P	P	112	70	160	p	p
17	11	021	DC1 (device control 1)	49	31	061	1	1	81	51	121	Q	Q	113	71	161	q	q
18	12	022	DC2 (device control 2)	50	32	062	2	2	82	52	122	R	R	114	72	162	r	r
19	13	023	DC3 (device control 3)	51	33	063	3	3	83	53	123	S	S	115	73	163	s	s
20	14	024	DC4 (device control 4)	52	34	064	4	4	84	54	124	T	T	116	74	164	t	t
21	15	025	NAK (negative acknowledge)	53	35	065	5	5	85	55	125	U	U	117	75	165	u	u
22	16	026	SYN (synchronous idle)	54	36	066	6	6	86	56	126	V	V	118	76	166	v	v
23	17	027	ETB (end of trans. block)	55	37	067	7	7	87	57	127	W	W	119	77	167	w	w
24	18	030	CAN (cancel)	56	38	070	8	8	88	58	130	X	X	120	78	170	x	x
25	19	031	EM (end of medium)	57	39	071	9	9	89	59	131	Y	Y	121	79	171	y	y
26	1A	032	SUB (substitute)	58	3A	072	:	:	90	5A	132	Z	Z	122	7A	172	z	z
27	1B	033	ESC (escape)	59	3B	073	;	;	91	5B	133	[	[	123	7B	173	{	{
28	1C	034	FS (file separator)	60	3C	074	<	<	92	5C	134	\	\	124	7C	174			|
29	1D	035	GS (group separator)	61	3D	075	=	=	93	5D	135	]	]	125	7D	175	}	}
30	1E	036	RS (record separator)	62	3E	076	>	>	94	5E	136	^	^	126	7E	176	~	~
31	1F	037	US (unit separator)	63	3F	077	?	?	95	5F	137	_	_	127	7F	177	&#127;	DEL

Source: www.LookupTables.com

Rješenje

- Sve “novo” i “neobično”
  - će se staviti u **tijelo** poruke
  - ali **kodirano** na određeni način
  - tako da se samo **standardni 7-bitni** znakovi koriste
- dvije **najčešće** korištene sheme kodiranja:
  - **Quoted-printable** encoding
    - **ostavlja** “normalne” (7-bitne) znakove kakvi jesu
    - ali one koji imaju 8. bit postavljen na “1” **kodira** koristeći tri znaka
      - prefiks “=“ i
      - dva 7-bitna ASCII znaka koji predstavljaju heksadekadski ASCII kod znaka
    - na primjer: **Ä → =C4**
  - **Base 64** encoding
    - **kodira sve znakove u poruci**
    - **3 bajta** se kodiraju **koristeći 4 bajta**
    - dobiju se svi “razumljivi znakovi” (7 bita) prilikom prijenosa

      ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz1234567890+/
    - posljedica je da je, poruka **33% veća**

Base 64 encoding

1. pretvara 3 uzastopna bajta poruke
2. u 8 bita (24 bita ukupno)
3. dijeli ih u 4 dijela od 6 bita (24 bita ukupno)
4. 64 (dekadsko) se dodaje na svaki dio
5. Što rezultira u stvaranju "razumljivih znakova"

1	Originalan tekst	N				i				z			
	ASCII kodiranje (dekadsko)	78				105				122			
2	Stvarni niz bitova originala	**01**	**00**	**11**	**10**	**01**	**10**	**10**	**01**	**01**	**11**	**10**	**10**
3	6-bitna interpretacija	19				38				37			58
4	BASE64 abeceda	T				m				l			6
5	Konačni (kodirani) niz bitova	**01010100**				**01101101**				**01101100**			**00110110**

- Svaki niz bitova može se kodirati u "razumljive znakove"
  - dakle i **binarni** sadržaji

Mali problem s Base 64

- **što ako duljina** sadržaja za kodiranje nije **višekratnik od 3**?

N				i				z				2					
01	00	11	10	01	10	10	01	01	11	10	10	00	11	00	**10**	**?**	**?**
T				m				l				6			M	**?**	

- onda, se nadopunjuje s nulama do potrebne dujline

N				i				z				2					
01	00	11	10	01	10	10	01	01	11	10	10	00	11	00	**10**	**00**	**00**
T				m				l				6			M	**g==**	

- i na zadnji kodirani znak se dodaje **poseban znak** “=“
  - stoga, kodirani blok može završiti sa 2, 1 ili 0 dodanih “=“ znakova (eng. padding)

Kodiranje poruka

- Korisnički agent obavlja
  - kodiranje i dekodiranje 8-bitnog sadržaja poruke
- No, moraju znati:
  - da je poruka ili njezini dijelovi **kodirani**
  - **kako** je kodirana
  - **parametre** sadržaja kako bi ih ispravno interpretirala
    - grafičke
    - audio , video
    - programi
    - itd.
- Zapravo, također trebamo:
  - moći uključiti **više dijelova** binarnih informacija
    - u istoj poruci
  - a također i održati kompatibilnost sa starijim sustavima

Rješenje: MIME

- **Multipurpose Internet Mail Extensions**
- metoda za prijenos **bilo kakvog tipa** podataka
  - posebni znakovi, formatirani tekst,
  - grafovi, fotografije, audio, video, programi, binarni podatci …
- unutar tijela standardne e-mail poruke
- koristeći posebnu metodu kodiranja sadržaja
  - QP, Base64
- koristeći posebna zaglavlja
  - MIME-Version:
  - Content-Description:
  - Content-Id:
  - Content-Transfer-Encoding:
  - Content-Type:

MIME metoda

- e-mail **poruka** i dalje ima
  - **zaglavlja** i **tijelo**
  - slijedi rfc822
- ali tijelo može imati **više dijelova**
  - dijelovi su odvojeni posebno oznakom
    - **jedinstven** skup **znakova**
      - **Koji se ne nalazi** nigdje drugdje u poruci
    - obično **počinje** s nizom **“--“ znakova**
      - --=_NextPart_000_00B2_01D11F57.F5457240
    - završava također s “--“ oznakom
- **svaki dio** ima vlastito (MIME) **zaglavlje** i **tijelo**
  - neka MIME zaglavlja su također i u zaglavljima poruke

MIME zaglavlja - osnove

- Na **početku** uvijek postoji **identifikacijsko polje**
  - osnovni oblik: **MIME-Version: 1.0**
  - varijacije:
    - MIME-Version: 1.0 (produced by FER Mailer)
    - MIME-Version: 1.(produced for CompFor)
      - Zaglavlje označavaju komentare (prema "starom" RFC 822)
- **Content-Type** zaglavlje oblika:
  - Content-Type: type/subtype *[;parameter]
    - Govori korisničkom agentu **što da radi**, **kako postupati** s privitkom
  - Na primjer:
    - Content-Type: text/plain; charset=us-ascii (Plain text)
    - Content-Type: text/plain; charset="us-ascii"
- "inicijalni" (predefinirani) tipovi
  - text, image, audio, video, application
- kompozitni tipovi
  - multipart, message
- mehanizam nadogradnje:
  - ili registrirati ih (pri organizaciji IANA)
  - ili neregistriranim tipovima dati prefiks "X-"

MIME tipovi sadržaja (Content types)

Primjer: Content-Type: video/x-ms-wmv

- Tekst
  - Običan – zadana vrijednost
    - text/css
  - Richtext
- Slike
  - GIF, JPEG, PNG, BMP, …
  - image/png
- Audio
  - audio/x-wav
- Video
  - video/x-ms-wmv
- Aplikacije
  - application/pdf
  - Octet-stream
  - Postscript
- Poruke
  - Rfc822
    - Enkapsulira drugu poruku
  - Partial
    - MIME dijeli više datoteka
  - External-body
    - referenca na externi izvor podataka
- Multipart
  - Mixed
    - Više sadržaja prati poruku
  - Alternative
    - Isti podatci su prikazani više puta
  - Parallel
    - Dijelovi se trebaju gledati istovremeno
  - Digest
    - Svaki dio je posebna “poruka”

MIME zaglavlja - kodiranje

- Content-Transfer-Encoding
  - može biti u zaglavlju svakog dijela
    - neobavezno - postoje default vrijednosti
  - označava tip kodiranja
    7bita / 8bita / binarno / quoted-printable / base64 / ietf-token / x-token
  - 7bita ~= 8bita ~= binarno – oznaka da nije bilo transformacije sadržaja
  - ietf-token - format definiran starnards track RFC-om
    - i registriran pri IANA
  - x-token – privatni aplikacijski format
    - nije registriran pri IANA
  - vnd.token – format specifičan za pojedinog proizvođača
- Content-Disposition
    - Označava gdje treba prikazati privitak
  - **Inline**
    - Prikaz će biti na mjestu gdje se nalazi u poruci
    - Na primjer: ubačena slika
  - **Attachment**
    - Pohranjen kao eksterna datoteka
  - parameters: filename, dates, size
    - Ime datoteke se obično koristi kod pohrane sadržaja

MIME primjer: jednostavan e-mail

mail_text.txt (~/fer/racfor/mime-base64-res/mail_simpletext) - GVIM

Open Save SaveAll Print Undo Redo Cut Copy

```
MIME-Version: 1.0
Received: by 10.28.141.130 with HTTP; Tue, 13 Oct 2015 05:45:23 -0800 (PST)
Date: Tue, 13 Oct 2015 14:45:23 +0100
Delivered-To: petar.djerasimovic@gmail.com
Message-ID: <CAHO3kj7sGBoHgopJ5LmBk=A6vH9qWtz=rLiTR5F_v0PR3PSosg@mail.gmail.com>
Subject: Demo mail plain text
From: Petar Djerasimovic <petar.djerasimovic@gmail.com>
To: Petar Djerasimovic <petar.djerasimovic@gmail.com>
Content-Type: text/plain; charset=UTF-8

Jednostavan demo mail, tzv "plain text format"
~
```

Tekstualni prikaz sadržaja

- Primjetiti:
  - tip je text/plain
  - samo zaglavlje i sadržaj
  - samo ASCII znakovi

MIME primjer: formatirani text

- Postoje dva sadržaja
  - svaki sa vlastitim Content-Type
- korisnički agent ih odvaja u dijelove

```
MIME-Version: 1.0
Received: by 10.28.141.130 with HTTP; Wed, 14 Oct 2015 09:56:29 -0800 (PST)
Date: Wed, 14 Oct 2015 18:56:29 +0100
Delivered-To: petar.djerasimovic@gmail.com
Message-ID: <CAHO3kj47=u6Oa-+cV4V5JEvYuzyVPt7Yy5GT6_-QNWFRbKDAcA@mail.gmail.com>
Subject: Demo formatirani tekst
From: Petar Djerasimovic <petar.djerasimovic@gmail.com>
To: Petar Djerasimovic <petar.djerasimovic@gmail.com>
Content-Type: multipart/alternative; boundary=001a114b2d665b73dd05237e61eb

--001a114b2d665b73dd05237e61eb
Content-Type: text/plain; charset=UTF-8

Ovo je *mail* s *formatiranim tekstom*

--001a114b2d665b73dd05237e61eb
Content-Type: text/html; charset=UTF-8
Content-Transfer-Encoding: quoted-printable

<div dir=3D"ltr">Ovo je <b>mail</b> s=C2=A0<i>formatiranim tekstom</i>.</di=
v>

--001a114b2d665b73dd05237e61eb--
```

MIME primjer: kodirani naslov

Naslov s jednim znakom: “Naslov_s_jednim_**ć**”

```
MIME-Version: 1.0
Received: by 10.28.141.130 with HTTP; Wed, 14 Oct 2015 10:51:45 -0800 (PST)
Date: Wed, 14 Oct 2015 19:51:45 +0100
Delivered-To: petar.djerasimovic@gmail.com
Message-ID: <CAHO3kj6-OgfXgx5hV3wrJC4WVDiMxv2BYerCb6fDz2Wf5T0m-A@mail.gmail.
Subject: =?UTF-8?Q?Naslov_s_jednim_=C4=87?=
From: Petar Djerasimovic <petar.djerasimovic@gmail.com>
To: Petar Djerasimovic <petar.djerasimovic@gmail.com>
Content-Type: multipart/alternative; boundary=001a114b07d6f9719705237f269d
```

Q = QP-encoding
B = BASE64

Kodiranje bira korisnički agent

Naslov s više znakova: Hrvatski znakovi izvan ASCII tablice su **ććđšž** odnosno veliko **ĆĆĐŠŽ**

```
MIME-Version: 1.0
Received: by 10.28.141.130 with HTTP; Wed, 14 Oct 2015 11:09:16 -0800 (PST)
Date: Wed, 14 Oct 2015 20:09:16 +0100
Delivered-To: petar.djerasimovic@gmail.com
Message-ID: <CAHO3ki4nMumLvhJ9n=Kz1d5TwzLqqvMJbmn9HihtfCM3qD1_TA@mail.gmail.com>
Subject: =?UTF-8?B?SHJ2YXRza2kgem5ha292aSBpenZhbiBBU0NJSSB0YWJsaWNlIHN1IMSNxIfEkcWhxb4gbw==?=
    =?UTF-8?B?ZG5vc25vIHZlbGlrbyDEjMSGxJDFoMW9?=
From: Petar Djerasimovic <petar.djerasimovic@gmail.com>
To: Petar Djerasimovic <petar.djerasimovic@gmail.com>
Content-Type: multipart/alternative; boundary=001a11443b1aa7168a05237f6582
```

MIME primjer: e-mail s priloženom video datotekom

- Content-Type: multipart/mixed
- E-mail sadrži:
  - **text** (text/plain)
  - s proslijeđenom e-mail porukom
    - sadrži **video** (video/mp4)
      - kao **privitak**

```
MIME-Version: 1.0
Received: by 10.28.141.130 with HTTP; Thu, 15 Oct 2015 07:53:07 -0800 (PST)
In-Reply-To: <563634fb.6116c20a.44fe.373c@mx.google.com>
References: <563634fb.6116c20a.44fe.373c@mx.google.com>
Date: Thu, 15 Oct 2015 16:53:07 +0100
Delivered-To: petar.djerasimovic@gmail.com
Message-ID: <CAHO3kj7BsKC0PJLEb0MrOUPF8ySg5ZrzDeKWxf81BSXCJ=7q8g@mail.gmail.com>
Subject: Fwd: Vib download link
From: Petar Djerasimovic <petar.djerasimovic@gmail.com>
To: Petar Djerasimovic <petar.djerasimovic@gmail.com>
Content-Type: multipart/mixed; boundary=001a1148ef6227d74305237ca818

--001a1148ef6227d74305237ca818
Content-Type: text/plain; charset=UTF-8

kratak film (596K)


---------- Forwarded message ----------
From:  <vib.download@gmail.com>
Date: Thu, Oct 15, 2015 at 4:51 PM
Subject: Vib download link
To: petar.djerasimovic@gmail.com


Your download link:
http://s3-eu-west-1.amazonaws.com/vibbed-videos/040658982ebbbfa6e3890bed156af1f7160e08f03

--001a1148ef6227d74305237ca818
Content-Type: video/mp4;
    name="040658982ebbbfa6e3890bed156af1f7160e08f03907eace5f60988d.mp4"
Content-Disposition: attachment;
    filename="040658982ebbbfa6e3890bed156af1f7160e08f03907eace5f60988d.mp4"
Content-Transfer-Encoding: base64
X-Attachment-Id: f_iggp58kc0

AAAAIGZ0eXBpc29tAAACAGlzb21pc28yYXZjMW1wNDEAAAAIZnJlZQAJLzttZGF0AAACrAYF//+o
3EXpvebZSLeWLNgg2SPu73gyNjQgLSBjb3JlIDE0MiByNTAgZGQ3OWE2MSAtIEguMjY0L01QRUct
NCBBVkMgY29kZWMgLSBDb3B5bGVmdCAyMDAzLTIwMTQgLSBodHRwOi8vd3d3LnZpZGVvbGFuLm9y

(. . .)

swAJKn0AAABhdWR0YQAAAFltZXRhAAAAAAAAACFoZGxyAAAAAAAAAABtZGlyYXBwbAAAAAAAAAAA
AAAAACxpbHN0AAAAJKl0b28AAAAcZGF0YQAAAAEAAAAATGF2ZjU2LjQuMTAx
--001a1148ef6227d74305237ca818--
```

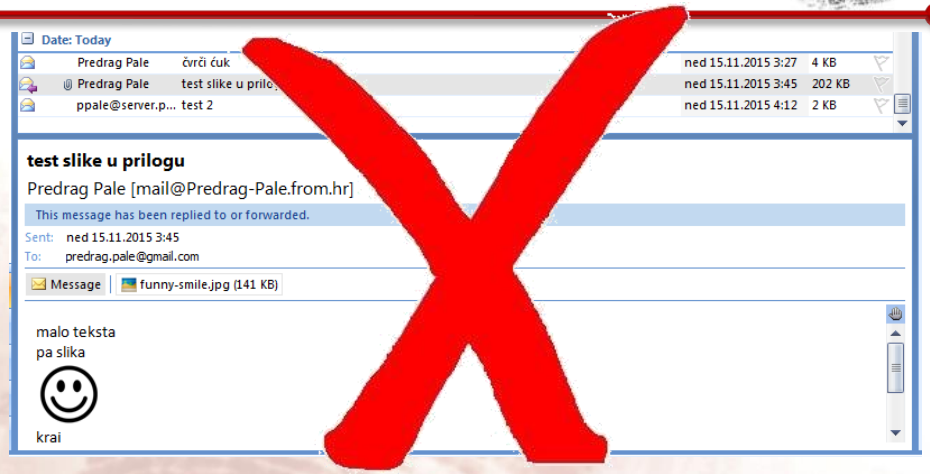
Ekstrakcija i dekodiranje sadržaja

- koristeći **e-mail** poruku iz prethodne prikaznice
  - zadnji dio poruke
    - **odvojen** zadnjim parom razdjelnika (eng. delimiter)
  - ručno je **pohranjen** u datoteku naziva "***encoded***"
  - i poslana na aplikaciju za dekodiranje "***base64***"
    - rezultat je pohranjen u datoteku naziva "***decoded***"
  - dva alata su se koristila za detekciju tipa sadržaja u datoteci
    - ***trID*** → detektira **MPEG-4** video
    - ***file*** → detektira **MPEG** v4

```
petar@asus$ head -n 3 encoded
AAAAIGZ0eXBpc29tAAACAGlzb21pc28yYXZjMW1wNDEAAAAIZnJlZQAJLzttZGF0AAACrAYF//+o
3EXpvebZSLeWLNgg2SPu73gyNjQgLSBjb3JlIDE0MiByNTAgZGQ3OWE2MSAtIEguMjY0L01QRUct
NCBBVkMgY29kZWMgLSBDb3B5bGVmdCAyMDAzLTIwMTQgLSBodHRwOi8vd3d3LnZpZGVvbGFuLm9y
petar@asus$ tail -n 2 encoded
swAJKn0AAABhdWR0YQAAAFltZXRhAAAAAAAAACFoZGxyAAAAAAAAAABtZGlyYXBwbAAAAAAAAAAA
AAAAACxpbHN0AAAAJKl0b28AAAAcZGF0YQAAAAEAAAAATGF2ZjU2LjQuMTAx
petar@asus$ base64 -d encoded > decoded
petar@asus$ trid -n:2 decoded
TrID/64 - File Identifier v2.20 - (C) 2003-15 By M.Pontello
Definitions found:  5968
Analyzing...
Collecting data from file: decoded
 36.7% (.M4V) MPEG-4 Video (70005/3/23)
 33.0% (.M4R) iPhone Ringtone (63004/2/19)
petar@asus$ file decoded
decoded: ISO Media, MPEG v4 system, version 1
```

Forenzička analiza privitaka

- MIME dijelovi mogu
  - **nedostajati**
  - **biti korumpirani**
    - **oštećeni**
    - **namjerno** izmijenjeni



- stoga, u analizi
  - **ne možemo se nasloniti na** obično čitanje privitaka
    - standardnim korisničkim agentima
  - **već moramo**
    - **analizirati** MIME dijelove
    - **ekstrahirati** ih u datoteke
    - koristiti posebne alate za konverziju
    - te provjeriti njihov **tip** i, konačno, provjeriti **sadržaj**

Šifriranje e-mail poruka

E-mail poruke se mogu šifrirati

- MIME se koristi
- MIME dijelovi su šifrirani
  - ali ne i zaglavlje poruke
  - S/MIME – Secure MIME
    - autentifikacija, integritet poruke, neporecivost izvora poruke, privatnost i tajnost podataka
    - Content_Type: application/pkcs7-mime
- nekoliko metoda
  - PGP- Pretty Good Privacy
  - GnuPG – GNU Privacy Guard

Što smo naučili

- Kako e-mail **putuje**
  - između MTA sustava (min 2)
  - između UA i MTA

- **Protokol**(i)
  - MTA koristi SMTP
  - UA koristi POP3 ili IMAP

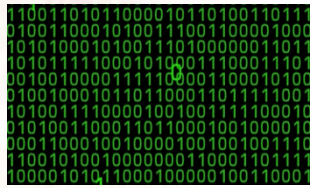
SMTP POP3 IMAP

- **Zaglavlja** poruka
  - mogu se krivotroviti
  - analizirati prvu (najnižu) “Received:” liniju zaglavlja

To: From: Date: Subject: Received:

- **Privitci** poruka
  - su u tijelu poruka
  - kodirani koristeći MIME
  - mogu biti ručno analizirani

MIME



- **Šifrirani** e-mail
  - MIME dijelovi su šifrirani
  - zaglavlaj nisu šifrirana
    - a ponekad i dijelovi tijela poruke

S/MIME

Standardi

- RFC 5321 – SMTP
  - stariji 2821, 821
- RFC 5322 – message format
  - stariji 2822, 822

- RFC 1939 – POP3
  - stariji 1722,1460, 1225, 1081
- RFC 1176 – IMAP
  - stariji 1203, 1064

- RFC 1521, 1522 – MIME
  - stariji : 1341, 1342
  - noviji: RFC 2045, 2046, 2047, 2048, 2049, 4288, 4289

- RFCs 3369, 3370, 3850, 3851 – S/MIME
- RFC 4880, 3156 – OpenPGP
  - stariji : 1991, 2440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