

Hang on...

Who put "inter" in the Internet ?!



Poul-Henning Kamp

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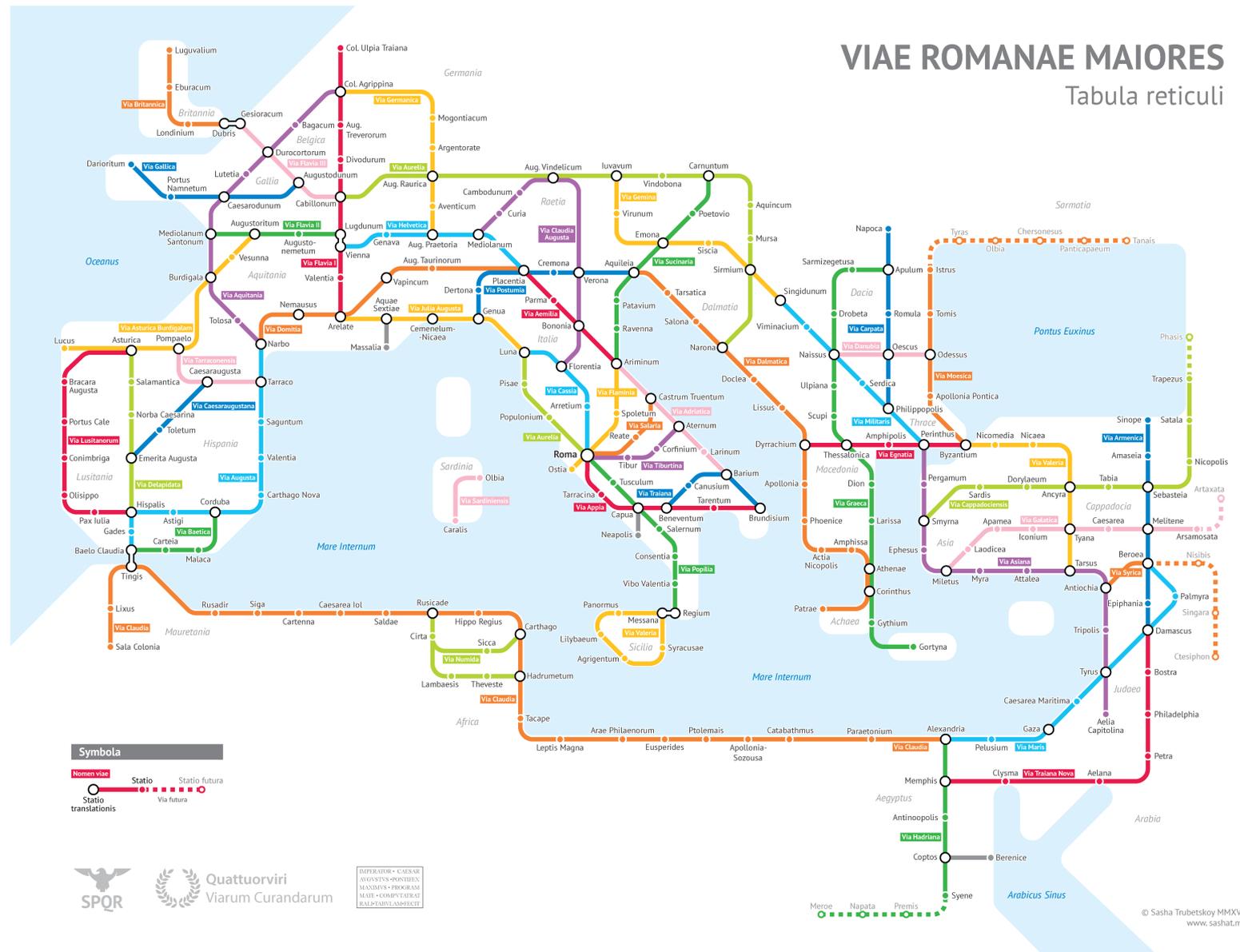
@bsdphk

Speed of light quiz

1. What is the speed of light ?
2. What was the speed of light 100 years ago ?
3. What was the speed of light 200 years ago ?
4. What was the speed of light 300 years ago ?
5. What was the speed of light 2000 years ago ?

VIAE ROMANAE MAIORES

Tabula reticuli



Augustus want news
"Cursus publicus"
Network of roads
& system of couriers
Speed of light:

0.5 to 1.85 m/s

Route, Switch & Peer

”Mansiones” = Routers
Night quarters
~ 40km apart

”Mutationes” = Switches
Stables
~ 12km apart

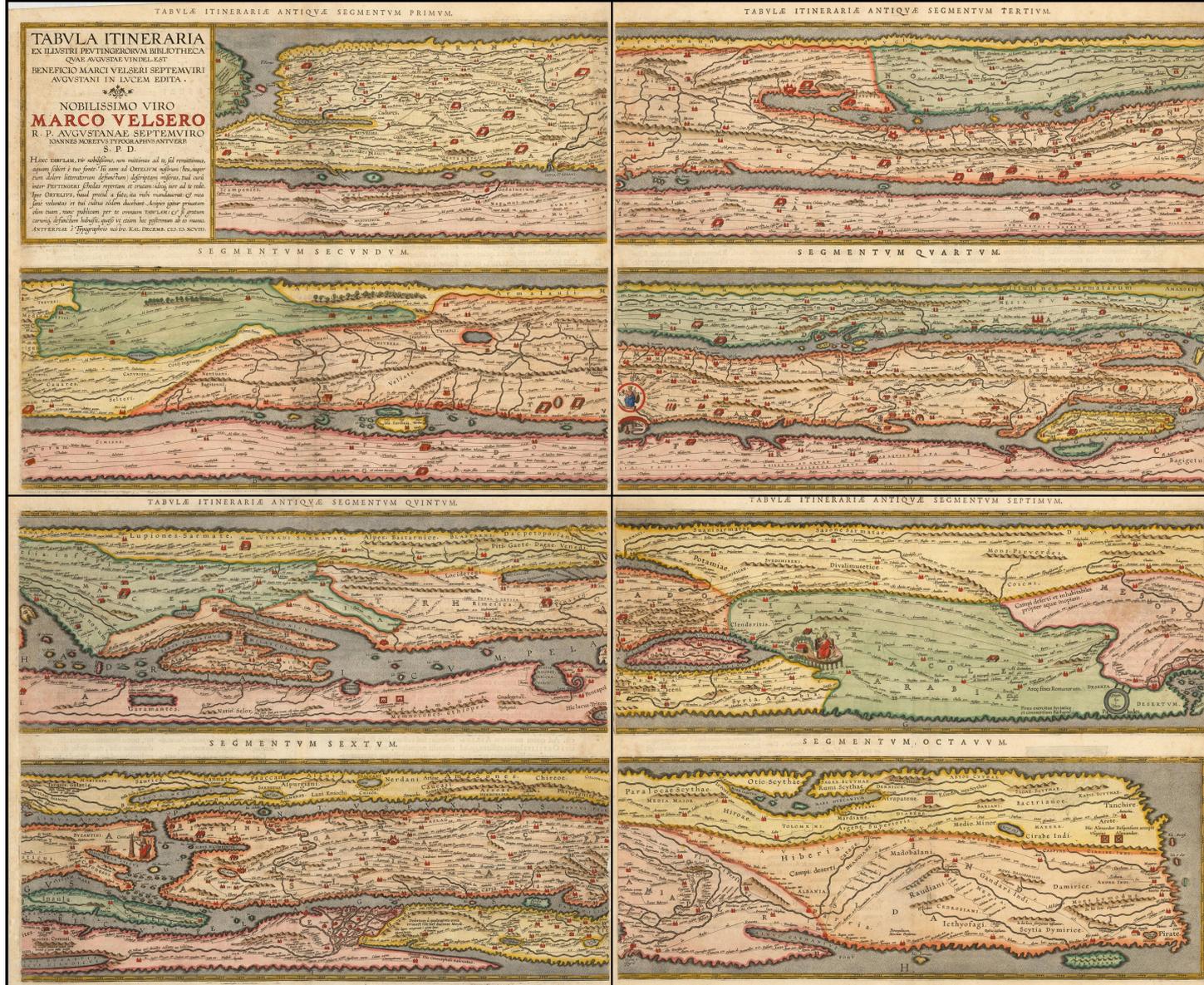
”Mancipes” = AS
Contractors

”Via Romanæ” = The links

Net result:

~160 km/day best case

~ 50 km/day typical



QoS and all that...

Packet loss: Unspecified, but very low.

Bandwidth: Undocumented, but significant.

The service was later split into "fast" and "slow" (aka "cursus clabularis"), with the slow service using pack-horses and ox-carts. (Large amounts of gold transported.)

Cost: HUGE

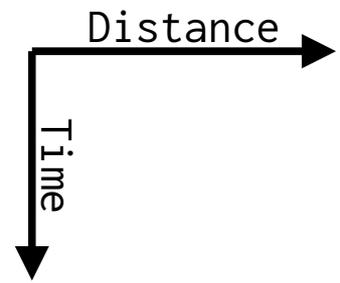
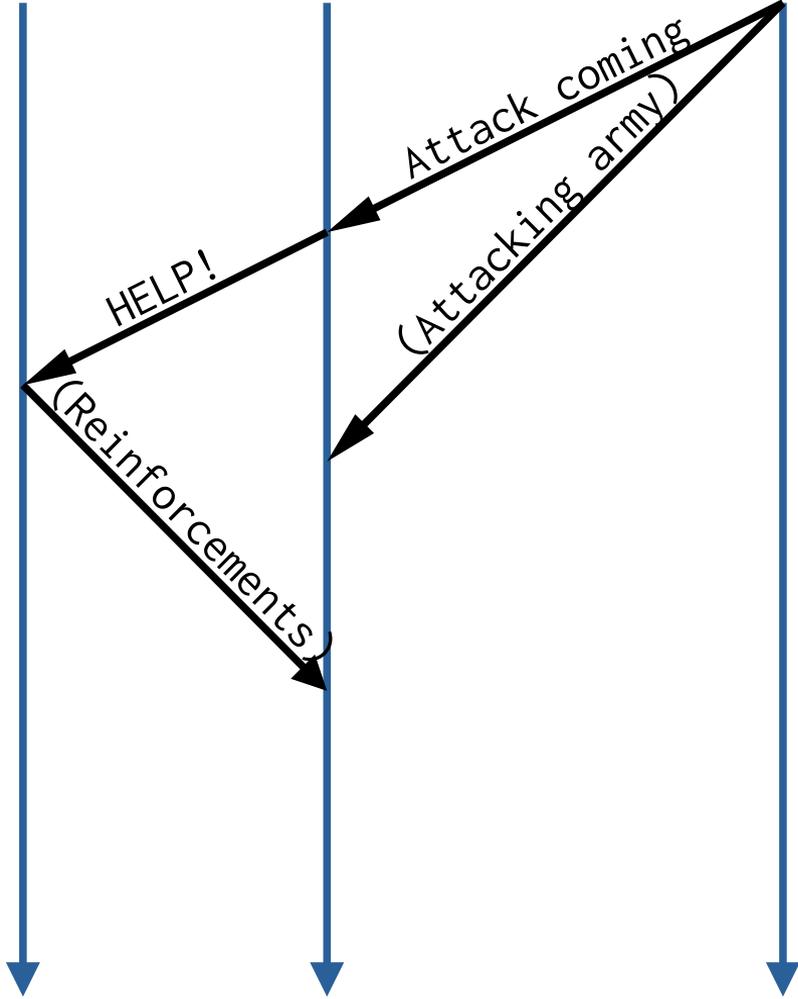
Uptime: Still in operation 500 years later.

RTT (Rome to Trier): 3 weeks

Friend

You

Enemy



But I saw optical communication in a documentary ?!



Technical specification:

Network name: Beacons of Gondor

Distance: 300-400 km

Hops: 8

E2E delay: 120 seconds (in the documentary)

Packet size: 1 bit

Packet rate: 1 packet per day (est.)

Cost: "Call us for a quote"

RFC 1149 "IP over Avian Carriers"

Distance: Up to 1000 km/hop

Speed: 27 m/s (one direction)

Packet size: 1500 MTU conjectured



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Distance: Up to 1000 km/hop

Speed: 27 m/s (one direction)

Packet size: 1500 MTU conjectured

Packet loss: 55% (actual measurement)

Vulnerabilities: Interference (in spring)
Man-in-the-middle



Seriously:

Carrier pigeons have played a major role in history

Probably more than 3500 years old technology

Extensively used during WW-I

Serious downsides:

Primary: Need to transfer pigeons all the time

Secondary: Loss, interception, variable delay

But a LOT faster than anything else available.

And then...

And then...

...nothing happens for almost 1800 years

Chappe's Optical Telegraph

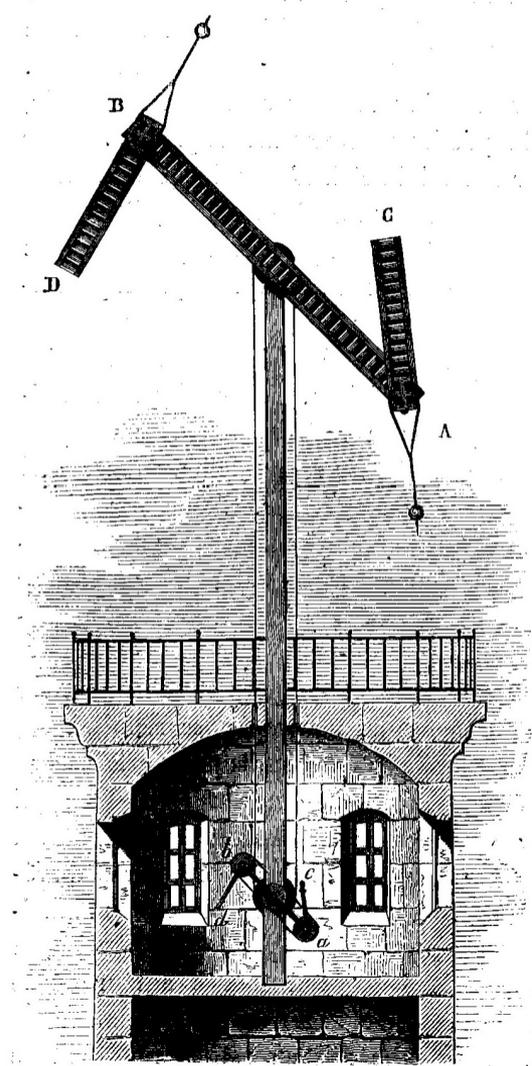


Fig. 19. — Télégraphe de Chappe.

Chappe's Optical Telegraph

Transmission protocol:

1. TX idle1
2. RX idle1
3. TX page#
4. RX page#
5. TX idle2
6. RX idle2
7. TX word#
8. RX word#
(goto 1)

Grille des signaux de correspondance

1	26	47	72
2	27	48	73
3	28	49	74
4	29	50	75
5	30	51	76
6	31	52	77
7	32	53	78
8	33	54	79
9	34	55	80
10	35	56	81
11	36	57	82
12	37	58	83
13	38	59	84
14	39	60	85
15	40	61	86
16	41	62	87
17	42	63	88
18	43	64	89
19	44	65	90
20	45	66	91
21	46	67	92
22		68	
23		69	
24		70	
25		71	

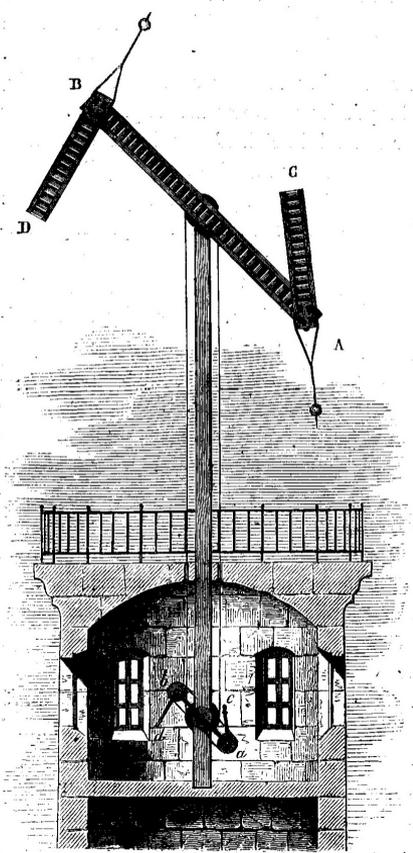
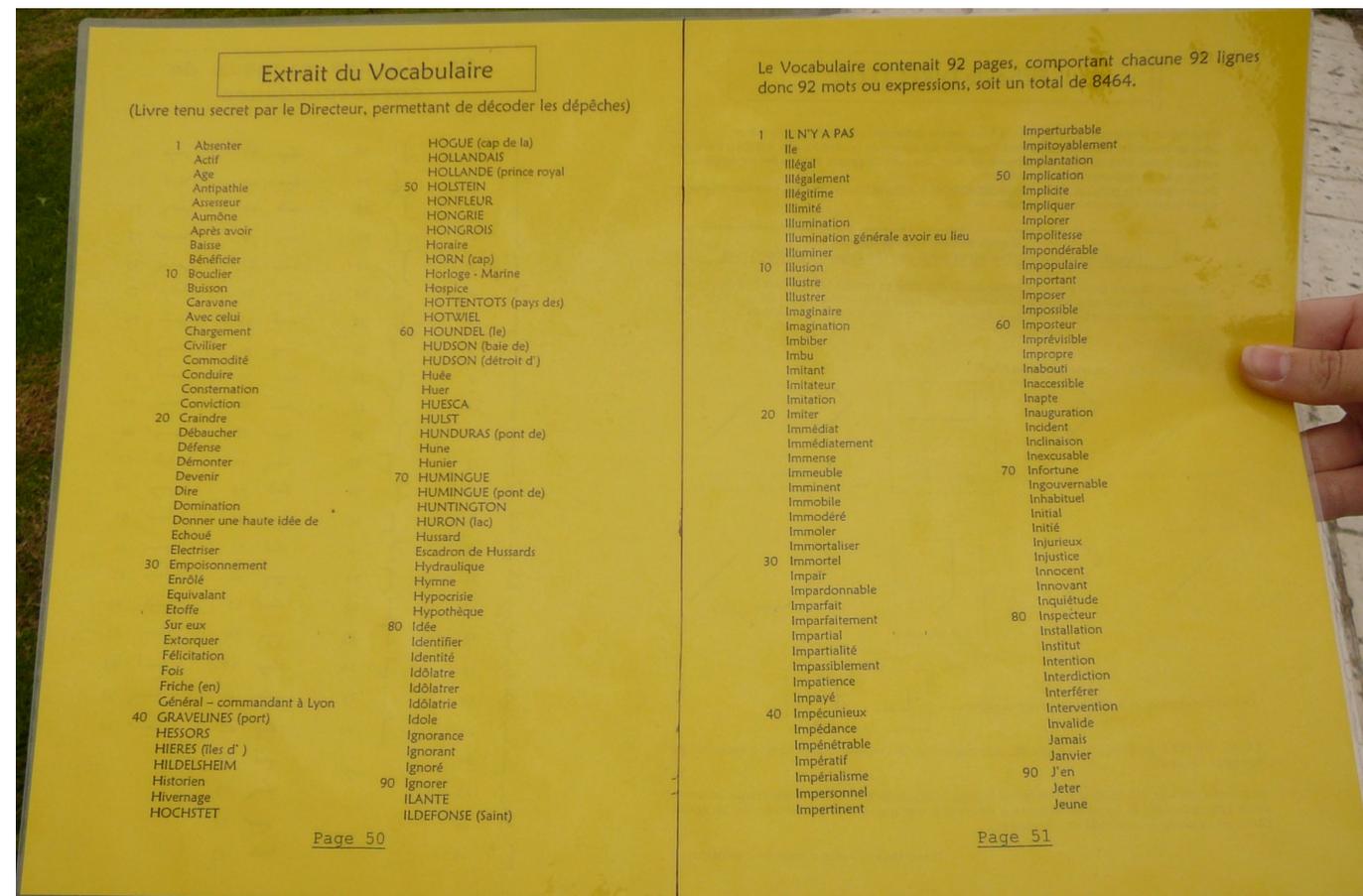


Fig. 19. — Télégraphe de Chappe.

Chappe's Optical Telegraph

Transmission protocol: "Codebook" has 92 pages with 92 words

1. TX idle1
2. RX idle1
3. TX page#
4. RX page#
5. TX idle2
6. RX idle2
7. TX word#
8. RX word#
(goto 1)



Chappe's Optical Telegraph

1793-07-12:

26km proof-of-concept transmission

1793-07-25:

Appointed National Telegraph Engineer

1793-08-04

Paris-Lille approved for construction

Chappe's Optical Telegraph

Payload alphabet: $92 \times 92 = 8464$

Half duplex

Hop-by-hop error correction

50% duty-cycle (= Daylight)

Transmission rate (E2E): $2\frac{1}{2}h \rightarrow$

Only for "official correspondence"

Ligne
de Bayonne

Dépêche Télégraphique De Paris
Du 24 Août 1838 à 3h. 1/2

Direction
de Toulouse.

Le Ministre Des Intérieurs
à M^{rs}. les Préfets et Sous-Préfets

1^{er} D^o
Coulou
2^e D^o
Main

M^{rs} la Duchesse D'Orléans
est accouché d'un Prince aujourd'hui à
Coulou 3 heures après midi.

Il a pour nom, par ordre Du Roi, le nom
de Louis-Philippe-Albert, Comte
M^{rs} de Paris.

L'accouchement a été fort heureux. Mad^{rs}
la Duchesse D'Orléans et le Prince nous causent
continuellement à être dans l'état de santé le
plus satisfaisant.

L'aites savoir immédiatement à toutes
les communes de votre Département cette
heureuse nouvelle.

42

Pour Copie
Toulouse le 24 Août 1838
à 6 heures du soir
Le Dir. du Télégraphe
C. Nozay

- ARCHIVES -
411 54
de la Haute-Garonne

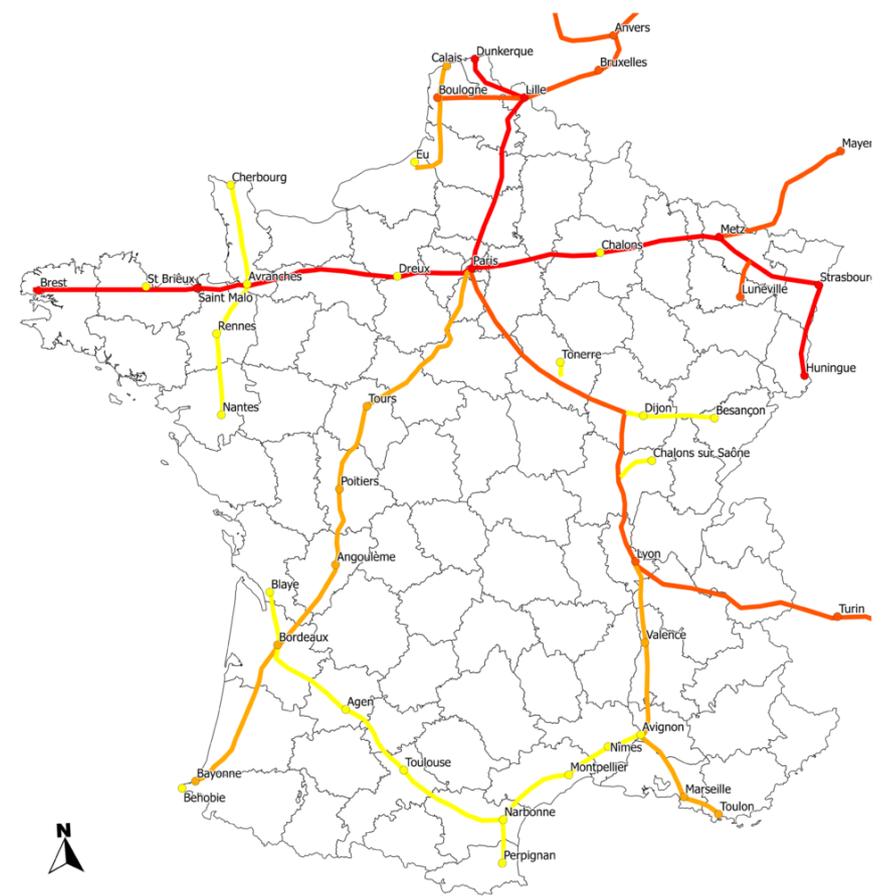
Chappe's Optical Telegraph

Paris-Strasbourg: 2 hours

Speed of light: 52 m/s

Courier: 3...4 days

TGV-train today: 2 hours



Le réseau Chappe en France

Directions (date de création)

- 1793-1800
- 1800-1815
- 1815-1830
- Après 1830

Lignes (date de création)

- 1793-1800
- 1800-1815
- 1815-1830
- Après 1830

Chappe's Optical Telegraph

First cyber-crime:

1834 Insider trading using Chappe's Telegraph

Acquitted: No law made it illegal.

The electro(-magnetic) Telegraph

Invented in 1753, 1774, 1804, 1809, 1820 & 1837

Had to invent the parts first:

- Electrochemical battery (1800, Volta)

- Electromagnetism (1820, Ørsted)

- Electromagnet (1828, Henry)

- Modulation (1837, Morse)

From there on it was just "product development"

The electro(-magnetic) Telegraph

1842 - demo between two rooms at Capitol Hill

1843 - \$30000 for WDC-Baltimore (61km)

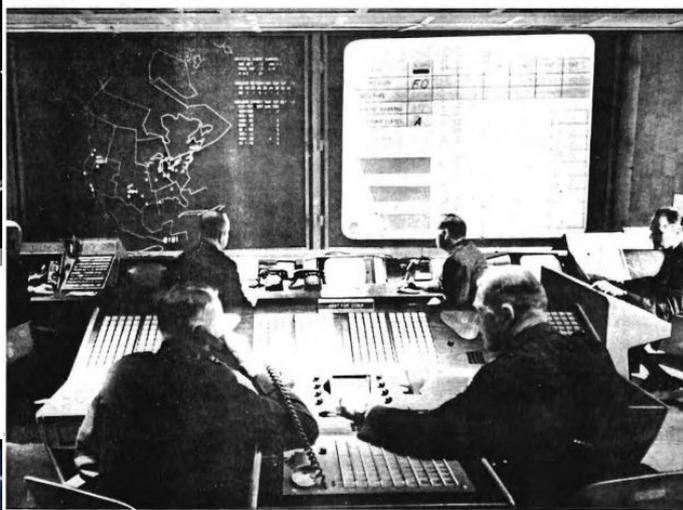
1844 - Jaw-dropping demo of the new line (= election result)

1850 - almost 20.000 km telegraph-lines in operation

1861 - 1st SF-WDC telegram, tx 19:40, rx 11:30, $c = 69 \text{ m/s}$

1861...5 - Telegraph instrumental in US Civil War (I)

Lincoln often waited for news in the telegraph office.



COMMAND POST IN THE UNDERGROUND COC



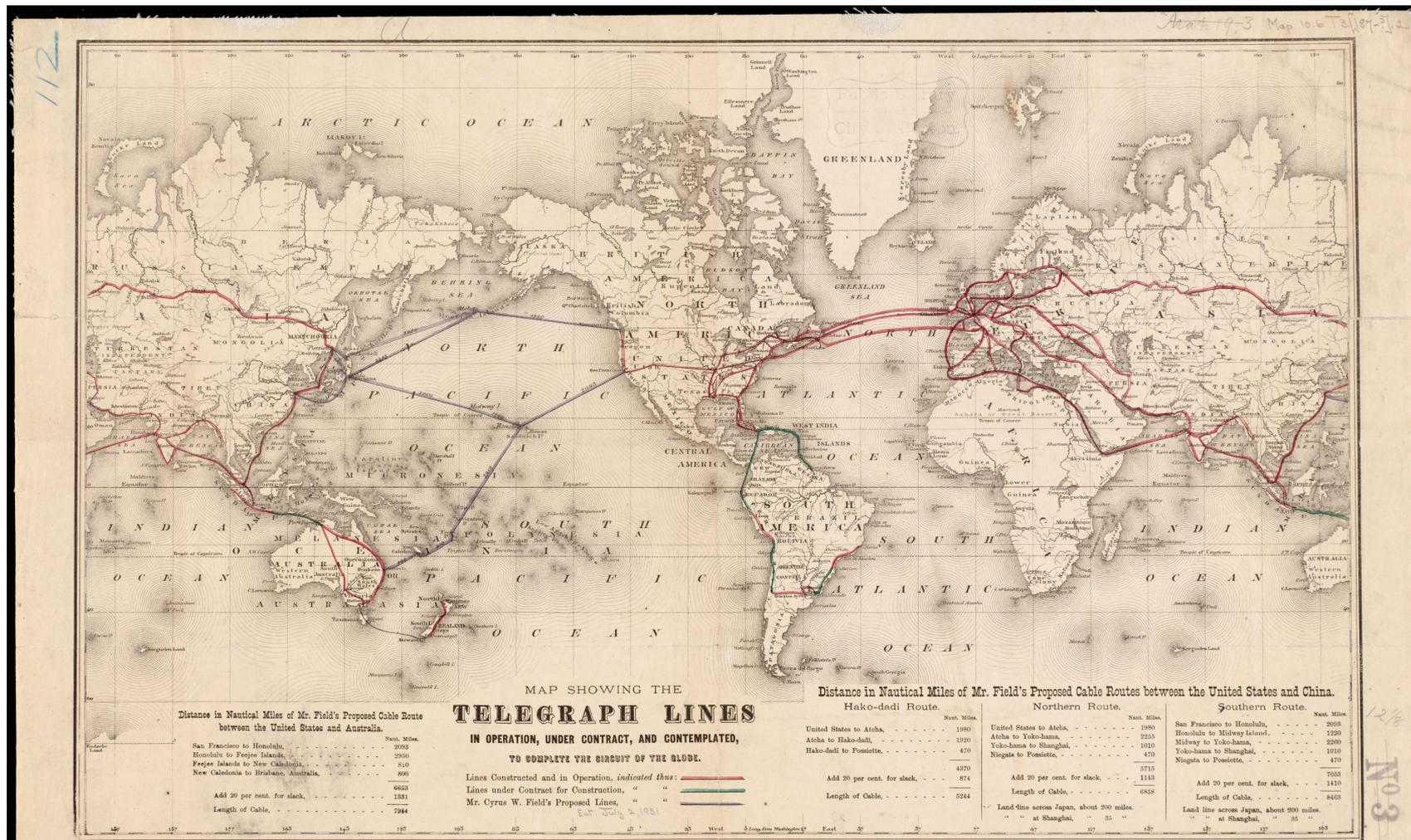
The electro(-magnetic) Telegraph

Status 1872:

Operational

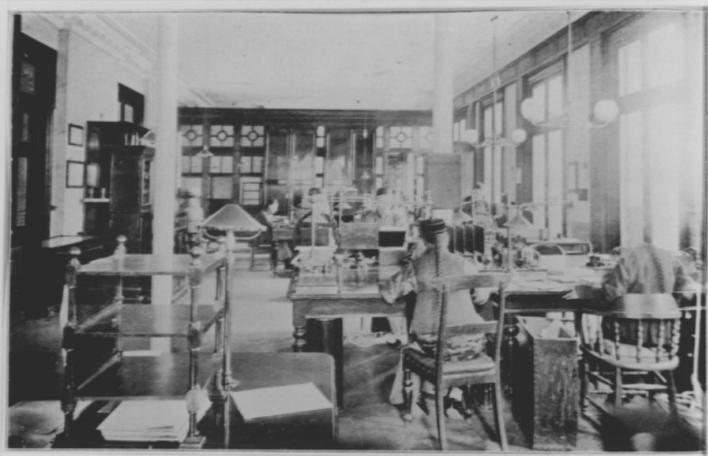
Construction

Planned



The electro(-magnetic) Telegraph

And it's all manual...



Skipping a LOT of interesting stuff here...

Material Technology

Electromagnetics

Polymer Chemistry

Transmission-Line theory

Longitudes & Timezones

Geophysics

Trains

...and how one constructs a telegraph line across Siberia



vby59/k439 white plains ny 27 26 1257 =

TELEGRAM



peter naun regnecentralen
gl cant sbengvej 2 valby =

tj. bem.

Telegrafstat
Valby
Valby Langgade



26. Jan. 1960

Dato:

lbnr. el. kvitt.	til	den	kl.	af
København 35 +				

do not agree to proposal cannot object because additional delay will
not produce more effective proposals = julien green john backus +

T 2 + 2009 ++

urgent iltelegram	mp udlev. egenhændigt	lt brevtelegram	xp bud betalt
is eftersendes	pc modtagelsesbevis	elt brevtelegram	rp svar betalt

A man in a black tuxedo and bow tie is sitting behind a dark desk. On the desk, from left to right, there is a clear glass bottle, a glass of water, a microphone on a stand, and a white rotary telephone. The background is a dark, out-of-focus field. The text "AND NOW FOR SOMETHING COMPLETELY DIFFERENT." is overlaid in white, bold, sans-serif font at the bottom of the image.

**AND NOW FOR SOMETHING
COMPLETELY DIFFERENT.**

There's this thing called "Governments"...

- * Cursus Publicus - Strictly for Government Business
- * Chappes Telegraph - Official business only
- * All countries censored cross-border mails and goods
- * All countries spied on each other
- * Diplomatic Correspondence encrypted (& broken)
- * In many countries: Encryption banned by law.

Telegraphy as a Threat To National Security

Domestic telegraphy: Go for it! Century of the fruitbat &c.

Cross-border traffic: Some Terms & Conditions apply

Typically two rules for international telegraphy:

- * All telegrams must be recorded
- * No secret codes allowed

Non-secret codes ?

Telegrams were priced "per word"

Spot the loophole(s) ?

Non-secret codes ?

Telegrams were priced "per word"

Spot the loophole(s) ?

Use UNICODE !

Bank rate has been reduced — Amellus
 ——— $\frac{1}{4}$ per cent. Amentia
 ——— $\frac{1}{2}$ per cent. Amerina
 ——— $\frac{3}{4}$ per cent. Amicitia
 ——— 1 per cent. Amiculum

Bankruptcy petition has been filed by — Amissio
 Bankruptcy proceedings have been taken
 against — Ammium

Bills. (Refer to ACCEPTANCE.)

Bills of Lading are not yet made out Ammonis
Bills of Lading are sent by this mail Amnicola
Bills of Lading have not been endorsed Amolior
Bills of Lading will be sent by next mail Amomis
 Have you sent *Bills of Lading* Ampelos
 How are *Bills of Lading* forwarded Amphora
 How are *Bills of Lading* made out Amplio
 Send *Bills of Lading* immediately Amplius

(Births)—Confined this morning, *Boy*, both
 doing well Ampulla
 Confined this morning, *Boy*, dead, Mother
 well Amputo
 Confined this morning, *Girl*, both doing
 well Amuletum
 Confined this morning, *Girl*, dead, Mother
 well Amusium
 Confined to-day, *Baby* dead, Mother fairly
 well Amussis
 Confined to-day, *Baby* dead, Mother weak Amygdala
 Confined to-day, *Baby* dead, Mother very
 weak Amylon
 Confined to-day, *Baby* dead, Mother fairly
 well, will telegraph again Amystis

Confined to-day, *Baby* dead, Mother weak,
 will telegraph again Anatinus
 Confined to-day, *Baby* dead, Mother very
 weak, will telegraph again Anceps
 Confined to-day, *Twins*, both *boys*, all well Ancilium
 Confined to-day, *Twins*, both *girls*, all well Ancilla
 Confined to-day, *Twins*, *boy and girl*, all well Ancon
 Confined to-day, *Twins*, one alive, a *boy*,
 Mother well Andabata
 Confined to-day, *Twins*, one alive, a *boy*,
 Mother weak Andron
 Confined to-day, *Twins*, one alive, a *boy*,
 Mother not expected to live Anellus
 Confined to-day, *Twins*, one alive, a *girl*,
 Mother well Anemone
 Confined to-day, *Twins*, one alive, a *girl*,
 Mother weak Anethum
 Confined to-day, *Twins*, one alive, a *girl*,
 Mother not expected to live Angina
 Confined to-day, *Twins*, both dead, Mother well Anguifer
 Confined to-day, *Twins*, both dead, Mother
 weak Anguinus
 Confined to-day, *Twins*, both dead, Mother
 not expected to live Anguipes
 Confined yesterday, *Boy*, both doing well Anguis
 Confined yesterday, *Boy*, dead, Mother well Angulus
 Confined yesterday, *Boy*, dead, Mother
 fairly well Angustia
 Confined yesterday, *Girl*, both doing well Anhele
 Confined yesterday, *Girl*, dead, Mother
 well Anicetum
 Confined yesterday, *Girl*, dead, Mother fairly
 well Aniciana
 Confined yesterday, *Twins*, both *boys*, all well Anilis
 Confined yesterday, *Twins*, both *girls*, all
 well Animalis

Confined yesterday, *Twins*, *boy and girl*, all
 well Animatio
 Confined yesterday, *Twins*, one alive, a *boy*,
 Mother well Animor
 Confined yesterday, *Twins*, one alive, a *boy*,
 Mother weak Animosus
 Confined yesterday, *Twins*, one alive, a *boy*,
 Mother not expected to live Anisum
 Confined yesterday, *Twins*, one alive, a *girl*,
 Mother well Annalis
 Confined yesterday, *Twins*, one alive, a *girl*,
 Mother weak Annavigo
 Confined yesterday, *Twins*, one alive, a *girl*,
 Mother not expected to live Annexus
 Confined yesterday, *Twins*, both dead, Mother
 well Annifer
 Confined yesterday, *Twins*, both dead, Mother
 weak Annona
 Confined yesterday, *Twins*, both dead, Mother
 not expected to live Annosus
Book is not yet published Annumero
Book is not published by us Annuntio
Book is out of print Anodyna
 The published price of the *book* is — Anonium
Book will be published about — Anormis
 Last edition of *book* completely sold out Ansatus
 New edition of *book* will be ready — Anteago
Bring home or order from— Antecedo
Bring home or order from the Stores — Antefero
Bring home or send at once — Antenna
Bring home with you — Antepono
Bring home with you from — Antequam
Bring home with you from the Stores — Antesto

Telecommunication in WW-I

1914: UK cuts Germany's Cable to USA

... as reported in
an Australian news-
paper, via telegram:

**GERMAN CABLE CUT ,
TELEGRAPHICALLY ISOLATED**

NEW YORK, August 5, 3.35 p.m.

The German-American cable has been cut eastward of the Azores, presumably by British warships. This act isolates Germany from cable intercourse except through channels controlled by Great Britain.

Telecommunication in WW-I

1917: UK intercepts
"The Zimmerman Telegram".

Breaks encryption.

"Suggest Mexico attack
USA, Germany promises
to help."

UK leaks to USA via CA

USA forced/dragged into WW-I on UK's side.

CLASS OF SERVICE DESIRED
Full Day Message
Day Letter
Night Message
Night Letter
From what office or person
ORIGINATE THE TELEGRAM
WILL BE TRANSMITTED AS A
FULL DAY MESSAGE

WESTERN UNION
TELEGRAM
NEWCOMB, CALTON, PRESIDENT

via Galveston

JAN 19 1917

GERMAN LEGATION
MEXICO CITY

130	13042	13401	8501	115	3528	416	17214	6491	11310
18147	18222	21560	10247	11518	23877	13805	3494	14936	
98092	5905	11311	10392	10371	0302	21290	5101	59695	
23571	17504	11289	18278	18101	0317	0228	17694	4473	
22224	22200	19452	21589	07893	5569	13918	8958	12137	
1333	4725	4458	5905	17106	13851	4458	17149	14471	6706
13850	12224	0929	14991	7382	15857	07893	14218	36477	
5870	17553	07893	5870	5454	16102	15217	22801	17138	
21001	17388	7440	23638	18222	0719	14331	15021	23845	
3150	23552	22096	21604	4797	9497	22401	20855	4377	
23610	18140	22200	5905	13347	20420	39689	13732	20667	
0929	5275	18507	52282	1340	22049	13339	11265	22295	
10439	14814	4178	6992	8784	7632	7357	6926	52262	11267
21100	21272	9340	9559	22404	15874	18502	18500	15857	
2188	5376	7381	98092	16127	13480	9350	9220	76036	14219
5144	2831	17920	11347	17142	11264	7087	7762	15099	9110
10482	97550	3509	3670						

Send the following telegram, subject to the terms
on back hereof, which are hereby agreed to

Cherpe German Embassy.

4.

4458	gemeinsam
17149	Freundschafts.
14271	⊙
6706	reichlich
13850	finanziell
12224	unterstützung
6929	und
14991	einverständnis
7382	ausserhalb.
15857	Paß
67893	Mexico.
14218	in
36477	Texas
5870	⊙
17553	neu
67893	Mexico.
5870	⊙
5454	AR
16102	IZ
15217	ON
22501	A

(Skipping a couple of wars here)

The TelCo networks are connection-oriented

- Not optimal for load-balancing
- Exponential growth in traffic
- 1962: T1 digital transmission
- 1977 50mm wave-guide @ 100 GHz
- Space, not time, multiplexing

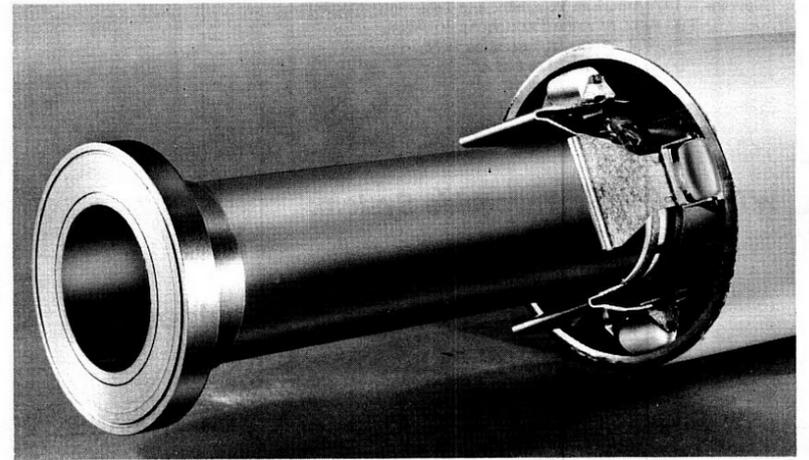


Fig. 1—Components of WT4 sheathed waveguide medium.



The TelCo networks are connection-oriented

- An obvious bad choice in a nuclear war

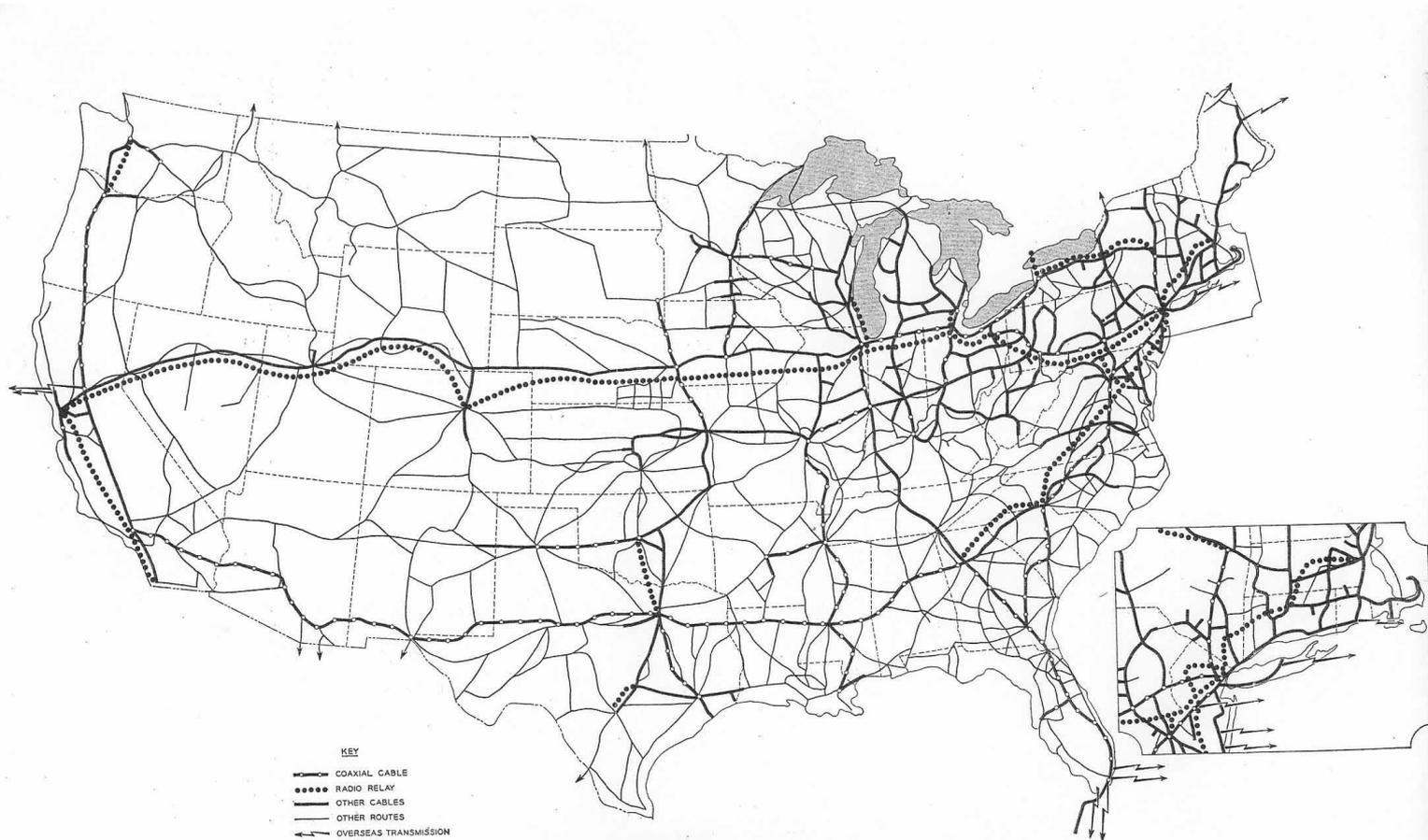


Fig. 4—Principal toll routes of the Bell System.

The TelCo solution: Underground telephone switches

No, not the bunker: Just the ventilation for the bunker



The TelCo solution: Underground telephone switches

No, not the bunker: Just the ventilation for the bunker



Progress in TelCo land

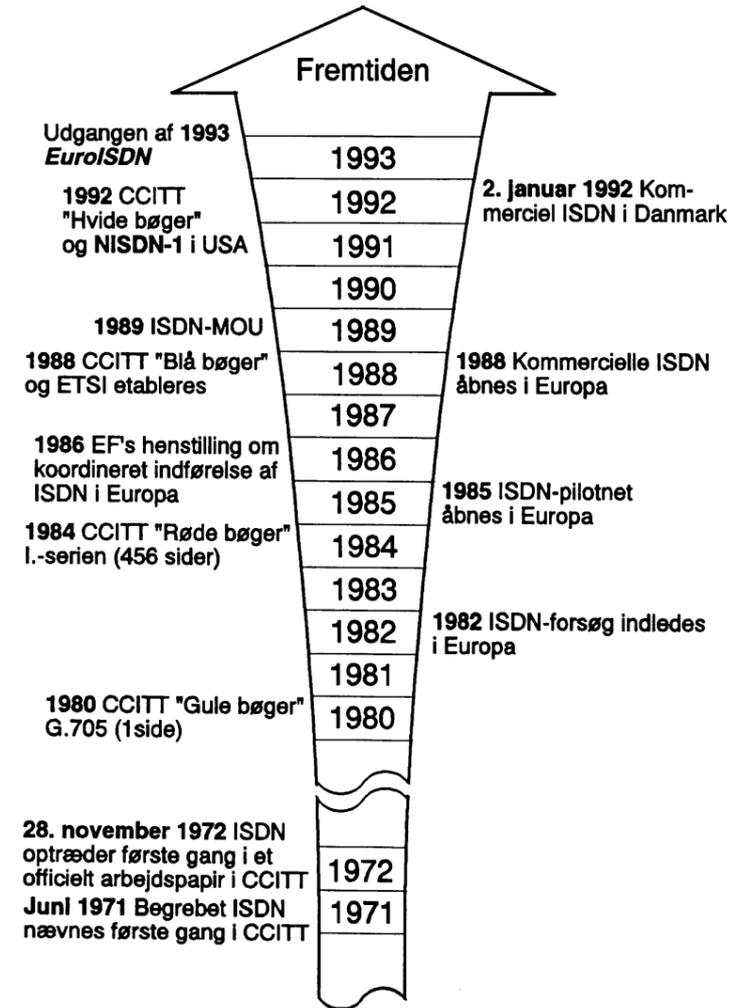
<u>Phone</u>	<u>Switch</u>	<u>Transmission</u>	
Analog	Analog	Analog	
Analog	Analog	Digital	"=DN"
Analog	Digital	Digital	"=IDN"
Digital	Digital	Digital	"=ISDN"

DN = Digital Network

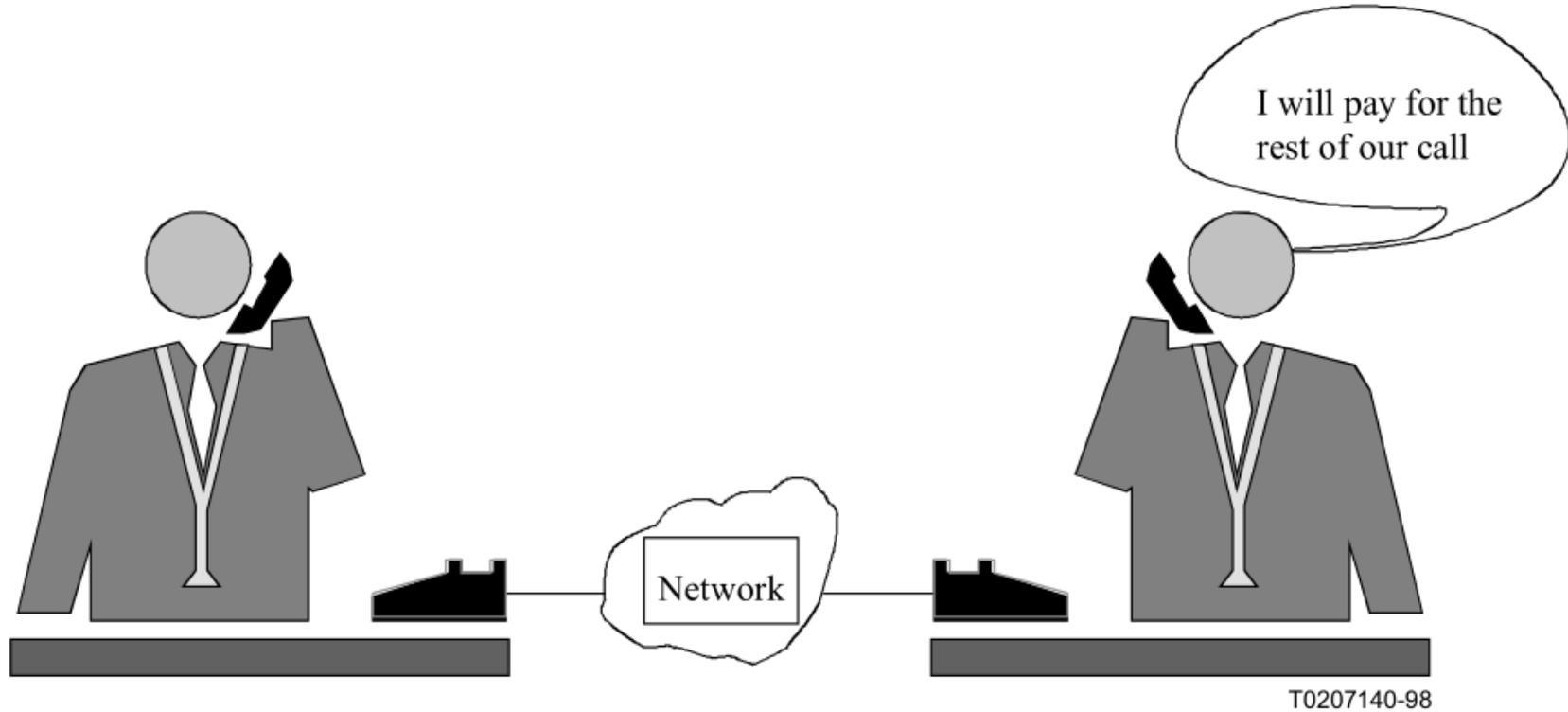
IDN = Intelligent Digital Network

ISDN = Intelligent Services Digital Network

ISDN fra "fødsel" til nu

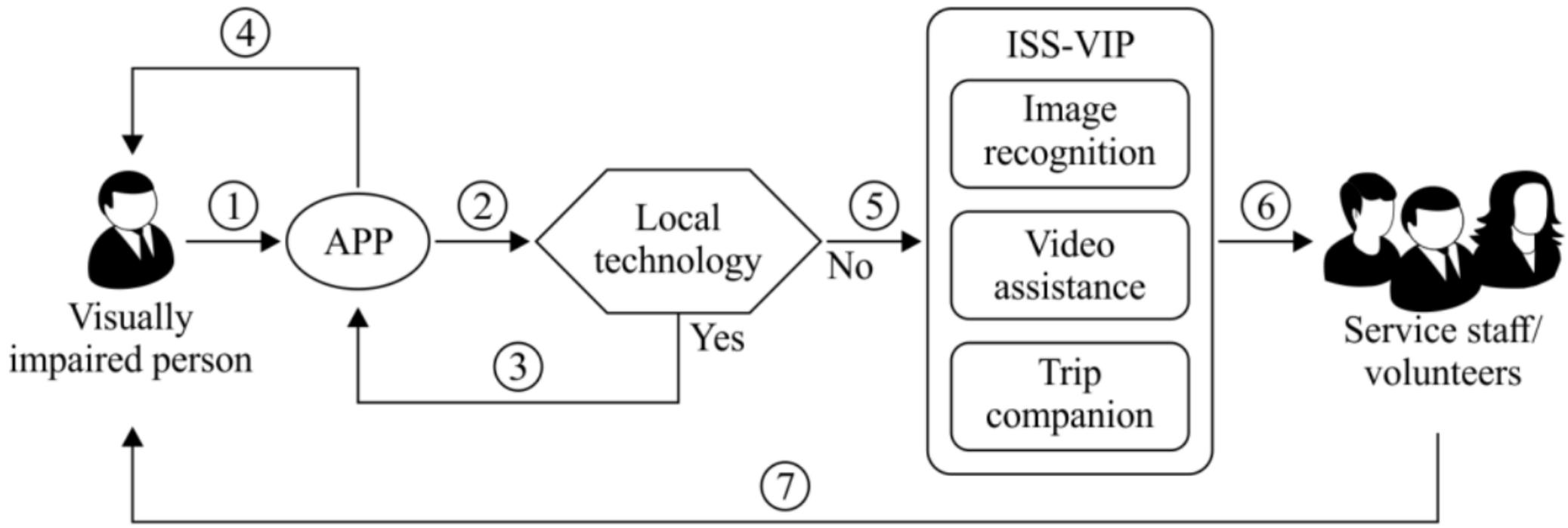


ISDN: Also (planning on) doing the hard bits



Case C: Reverse charging for the entire call requested by the called party during the active phase of the call

ISDN: Also (planning on) doing the hard bits



Jan 15th 1990

[UPI Archives](#)

AT&T service disrupted nationwide

By CLIFFORD J. LEVY

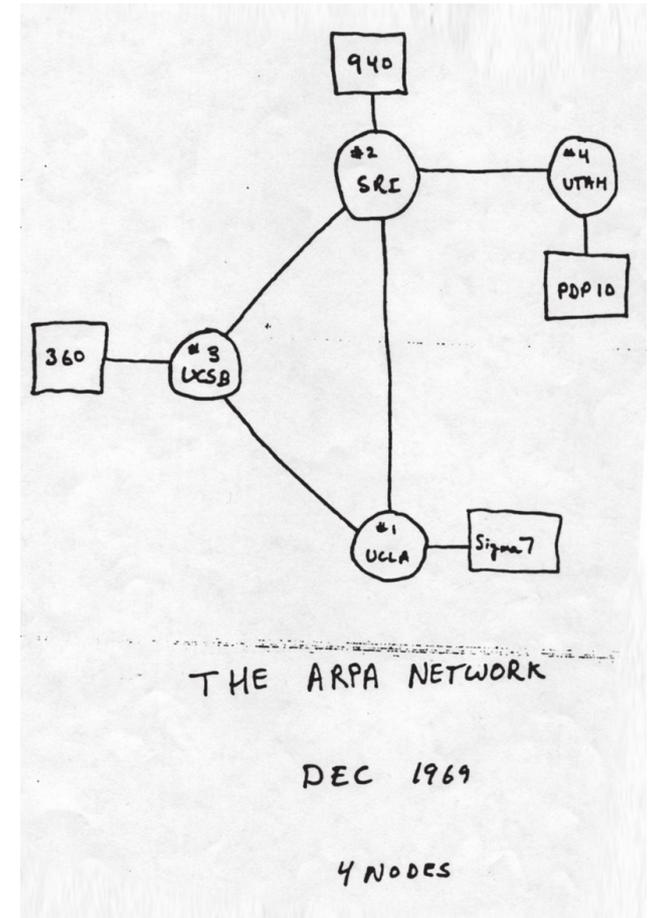
NEW YORK -- American Telephone & Telegraph Co. long-distance service was disrupted nationwide Monday by a computer problem that triggered a false circuit overload signal and blocked most customers from phoning out of their local calling areas.

Service was crippled about 2:20 p.m. EST, [...]

[...] by 7 p.m. EST, about half of all calls attempted were going through [...]

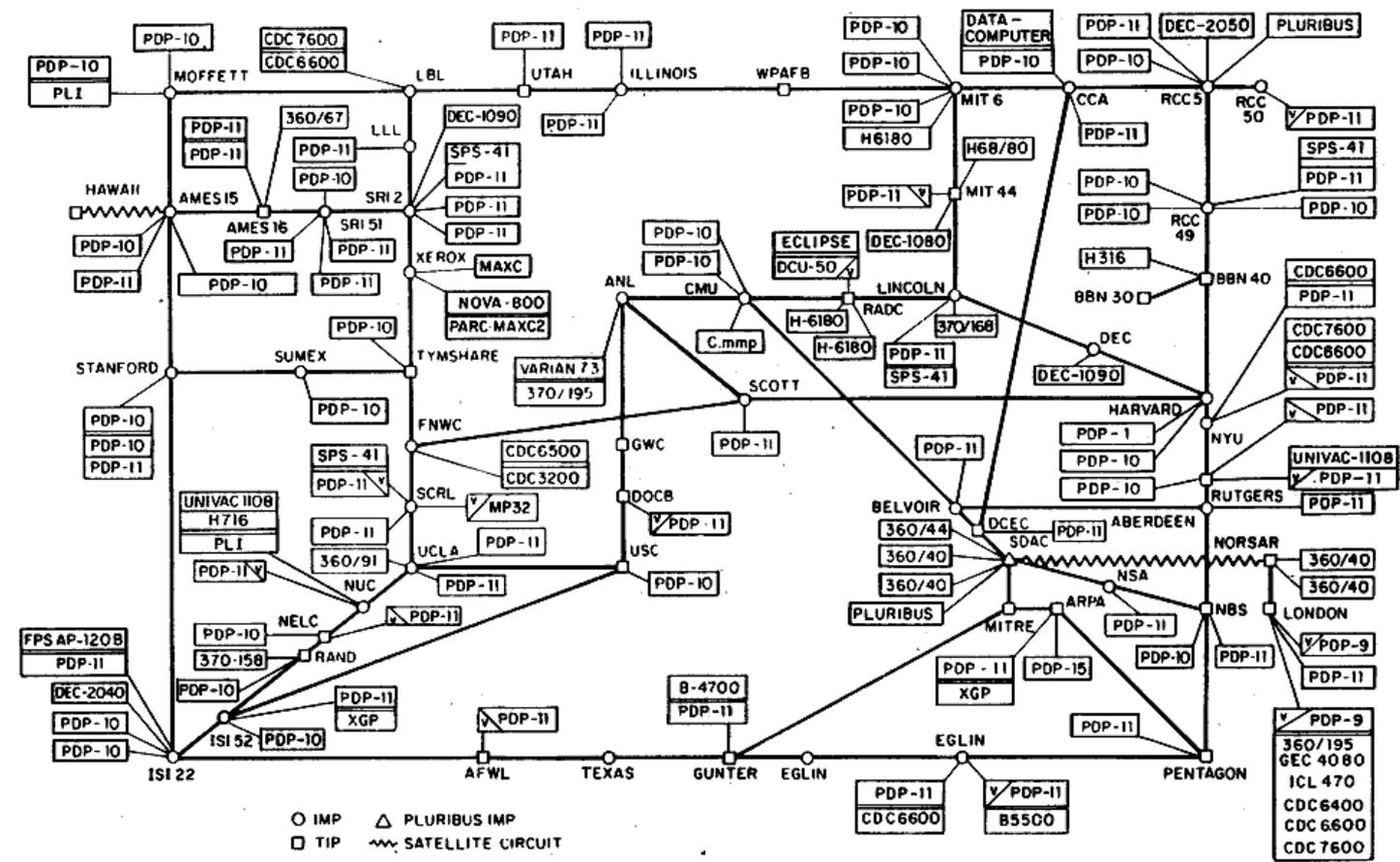
29oct69 22:30 Talked to SRI Host to Host

29oct69	2100	LOADED OP. PROGRAM FOR BEN BARKER BBV	CSK
	22:30	Talked to SRI Host to Host	CSK
		Left op. program running after sending a host dead message to imp.	CSK



The packet-switching idea

ARPANET LOGICAL MAP, MARCH 1977



(PLEASE NOTE THAT WHILE THIS MAP SHOWS THE MOST POPULATION OF THE NETWORK ACCORDING TO THE BEST INFORMATION OBTAINABLE, NO CLAIM CAN BE MADE FOR ITS ACCURACY)

NAMES SHOWN ARE IMP NAMES, NOT (NECESSARILY) HOST NAMES

Northern + Western - The first Internet ?

Two independent routes from Asia to Europa

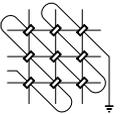
Same price

Often also same office

Same on-wire modulation

Same message format

Come visit Datamuseum.dk



New exhibition: The Modem-Age.

1st sunday each month.

Groups by appointment.