Digital Radio Communications

Objective

Understand how a digital communications station works,

Understand how to set-up a digital communications station,

Understand how to operate it

BUILD ONE!!!!!

Two Session Talk

- First Session – Digital Transmission & Reception Concepts

- Second Session - Hands-on Set-up your own radio

Talk Outline

- Concepts Session
  - Overview of Digital Radio Communications
  - Terms:
    - Digital
    - BIT
    - BYTE
    - BAUD
    - TNC
    - MODEM
  - Overview of Packet Radio Relaying
  - How digital communications are sent over Amateur Radio Frequencies
  - Radio Messaging System
  - Preview of required equipment and software required to perform digital communications in the VHF (2 Meter) & UHF (70 cm) Ham Radio Bands
- Demonstrate Software installation & configuration
- Hands-on Workshop
  - Install Software
  - Connect computer to radio through supporting equipment
  - Send Mail

Digital Radio Communications

- What is it?
  - For us, it's a method of sending and receiving email messages, chat texts, even photos & documents over your radio to another radio or for retrieval via the internet.

Let’s back up a bit ….

- What is “DIGITAL”
  - In the context of both computers & digital communications, digital means data expressed as series of 0’s and 1’s called ….
    - *BINARY numbers*
- What are and Why use Binary numbers?
  - Binary numbers easily represent something that is either ON or OFF
    - Examples
      - A Light bulb
      - An ON/OFF switch
      - A single transistor in an electronic circuit
  - They can also easily represent something that has two states or conditions
    - Morse Code -> DOT or DASH
    - Audio tone -> A LOW / HIGH pitch audio Tone

This is where we are headed

Light Bulb Example

- Let’s assign 1 and 0 to the light bulb state
  - Light bulb ON = 1
  - Light bulb OFF = 0
- Tah Dah!!!! Voila!! A binary system in your living room

A bit more binary

- Now let’s say we have 3 light bulbs
  - And agree that
    - Bulb 1 has a weight of 1 when ON, but 0 when OFF
    - Bulb 2 has a weight of 2 when ON, but 0 when OFF
    - Bulb 3 has a weight of 4 when ON, but 0 when OFF

Bulb 3	Bulb 2	Bulb 1	Binary Number	Decimal Number
OFF	OFF	OFF	0 0 0	0
OFF	OFF	ON	0 0 1	1
OFF	ON	OFF	0 1 0	2
OFF	OFF	OFF	0 1 1	3
ON	OFF	OFF	1 0 0	4
ON	OFF	ON	1 0 1	5
ON	ON	OFF	1 1 0	6
ON	ON	ON	1 1 1	7

Binary Representation

- Example of 1’s & 0’s representation
- By convention (fancy word for agreement)
  - The letter ‘A’ is represented by decimal number 65 and binary number 01000001
  - The letter ‘B’ is represented by decimal number 66 and binary number 01000010
  - The letter ‘C’ is represented by decimal number 67 and binary number 01000011
  - The letter ‘D’ is represented by decimal number 68 and binary number 01000100
  - The letter ‘E’ is represented by decimal number 69 and binary number 01000101

- There is a representation for every character on your keyboard

ASCII TABLE

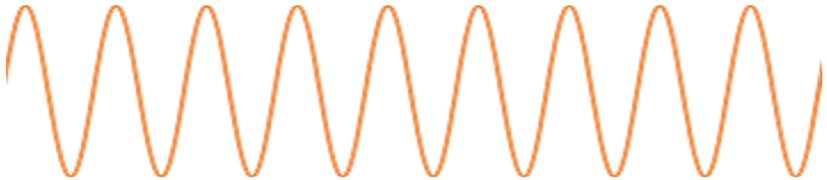
American **S**tandard **C**ode
for
Information **I**nterchange

ASCII for short

Character	Digital Representation	Character	Digital Representation	Character	Digital Representation
Space	0100000	@	01000000	`	01100000
!	0100001	A	01000001	a	01100001
"	0100010	B	01000010	b	01100010
#	0100011	C	01000011	c	01100011
$	0100100	D	01000100	d	01100100
%	0100101	E	01000101	e	01100101
&	0100110	F	01000110	f	01100110
'	0100111	G	01000111	g	01100111
(	0101000	H	01001000	h	01101000
)	0101001	I	01001001	i	01101001
*	0101010	J	01001010	j	01101010
+	0101011	K	01001011	k	01101011
,	0101100	L	01001100	l	01101100
-	0101101	M	01001101	m	01101101
.	0101110	N	01001110	n	01101110
/	0101111	O	01001111	o	01101111
0	0110000	P	01010000	p	01110000
1	0110001	Q	01010001	q	01110001
2	0110010	R	01010010	r	01110010
3	0110011	S	01010011	s	01110011
4	0110100	T	01010100	t	01110100
5	0110101	U	01010101	u	01110101
6	0110110	V	01010110	v	01110110
7	0110111	W	01010111	w	01110111
8	0111000	X	01011000	x	01111000
9	0111001	Y	01011001	y	01111001
:	0111010	Z	01011010	z	01111010
;	0111011	[	01011011	{	01111011
<	0111100	]	01011100 |	01111100
=	0111101	\	01011101	}	01111101
>	0111110	^	01011110	~	01111110
?	0111111	_	01011111	delete	01111111

Digital Communications

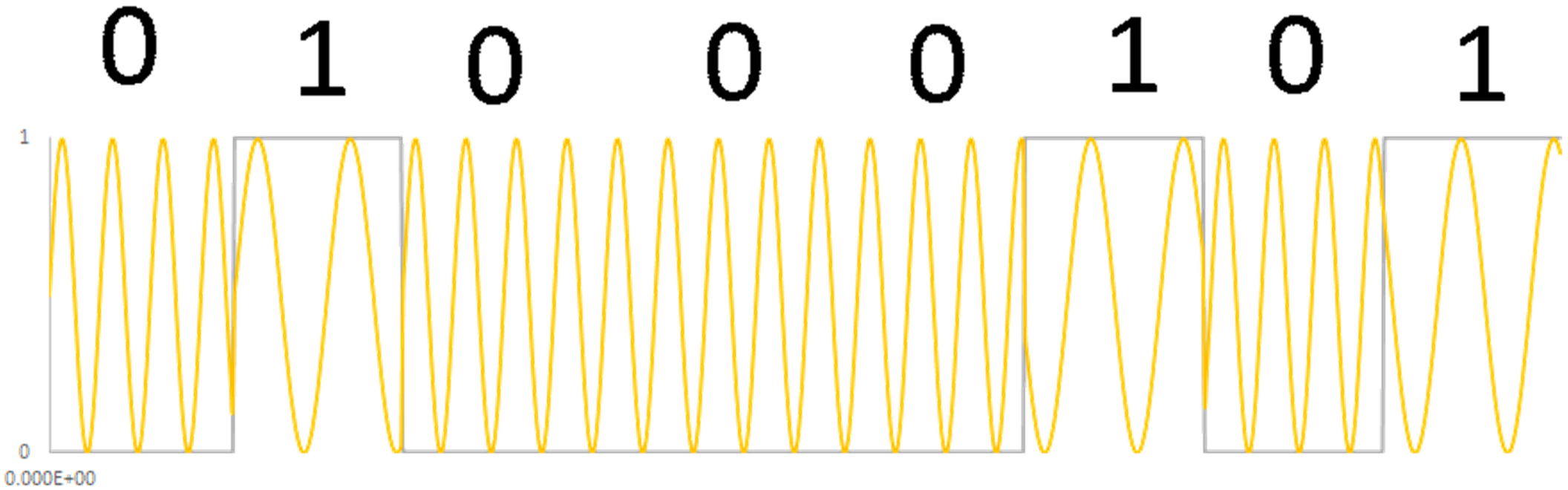
- Transmitting 1’s & 0’s over ham radio frequencies
  - Convert 1’s & 0’s to audio
    - Assign a unique tone to 0 & 1
      - 0 = 2200 Hz tone



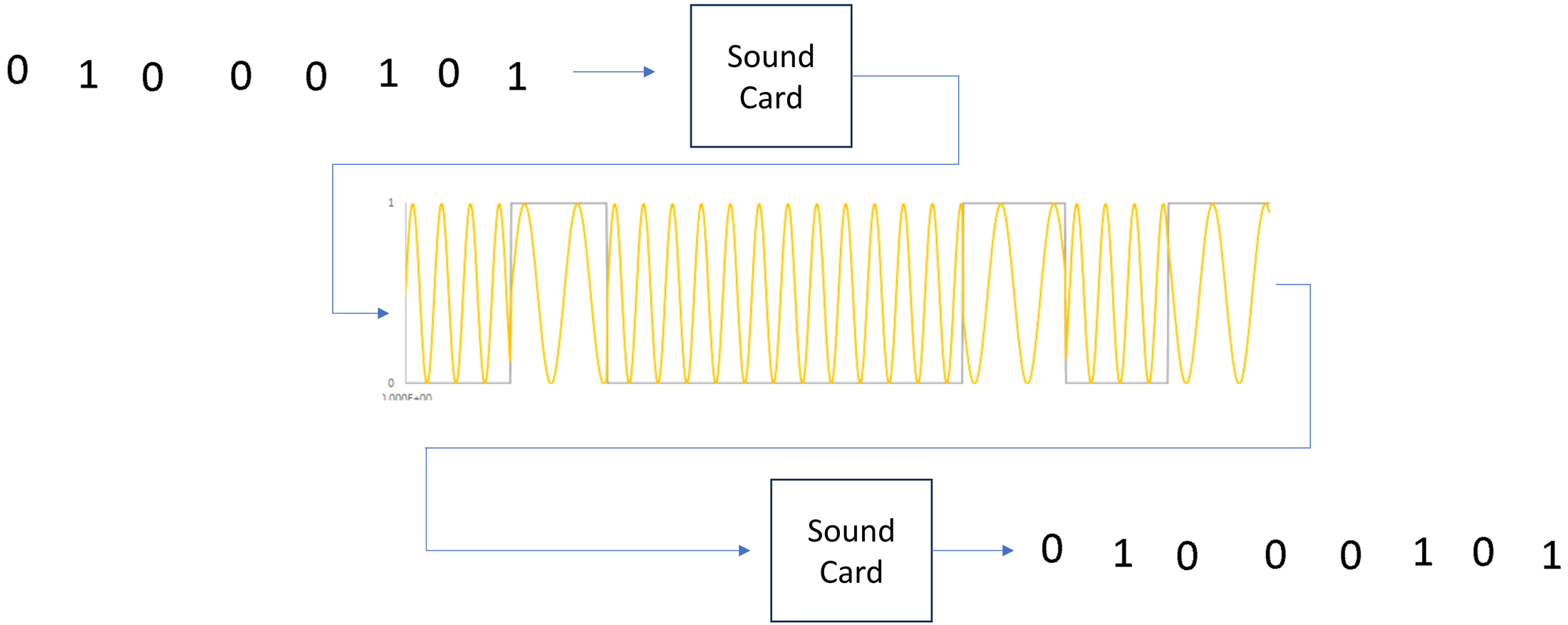
      - 1 = 1200 Hz tone

Play Live Audio Tones

Tone Encode the character ‘E’



Tone Encode & Decode

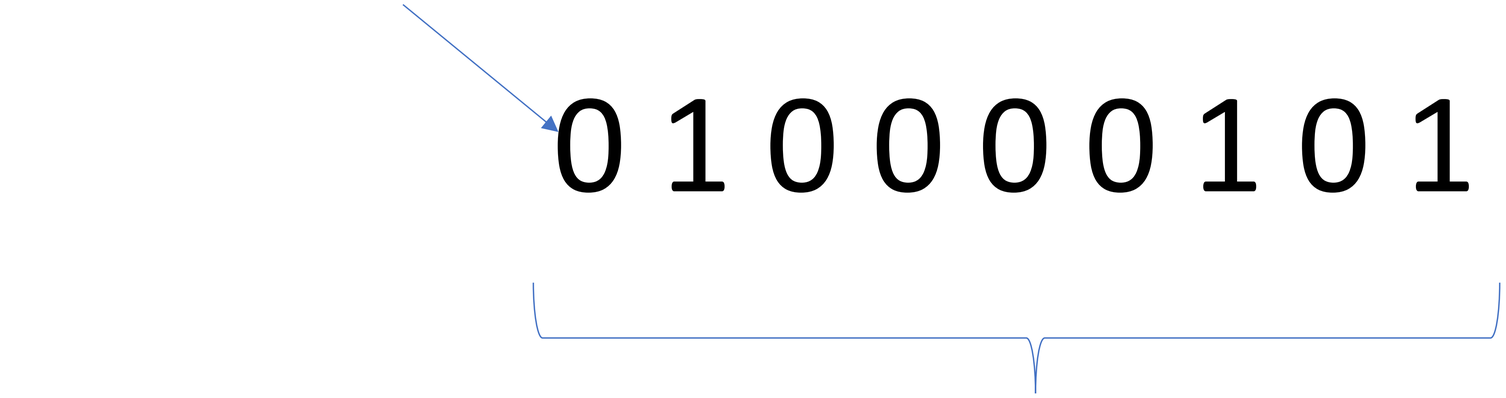


Let’s digress for a moment

To talk about BITS & BYTES

Bits and Bytes

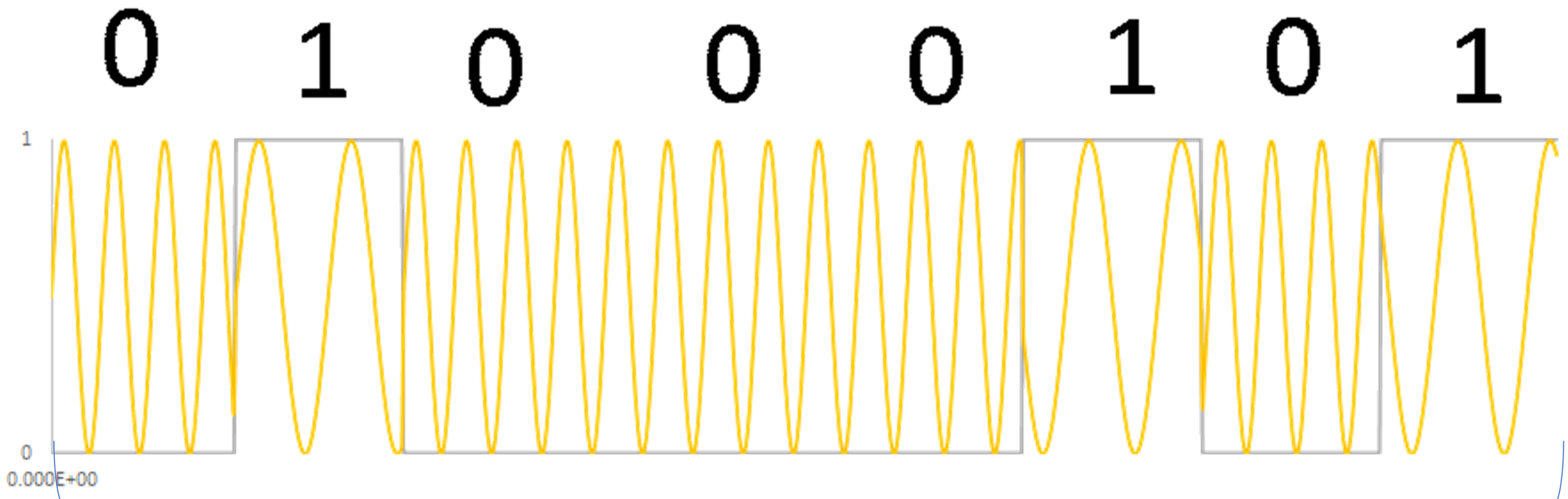
A Single Digit is a ‘bit’



8 bits make a ‘byte’

Bit Rate and BAUD

- Transmission Speed is expressed in bit/second



Let’s take a break

Back to Tone Encode & Decode

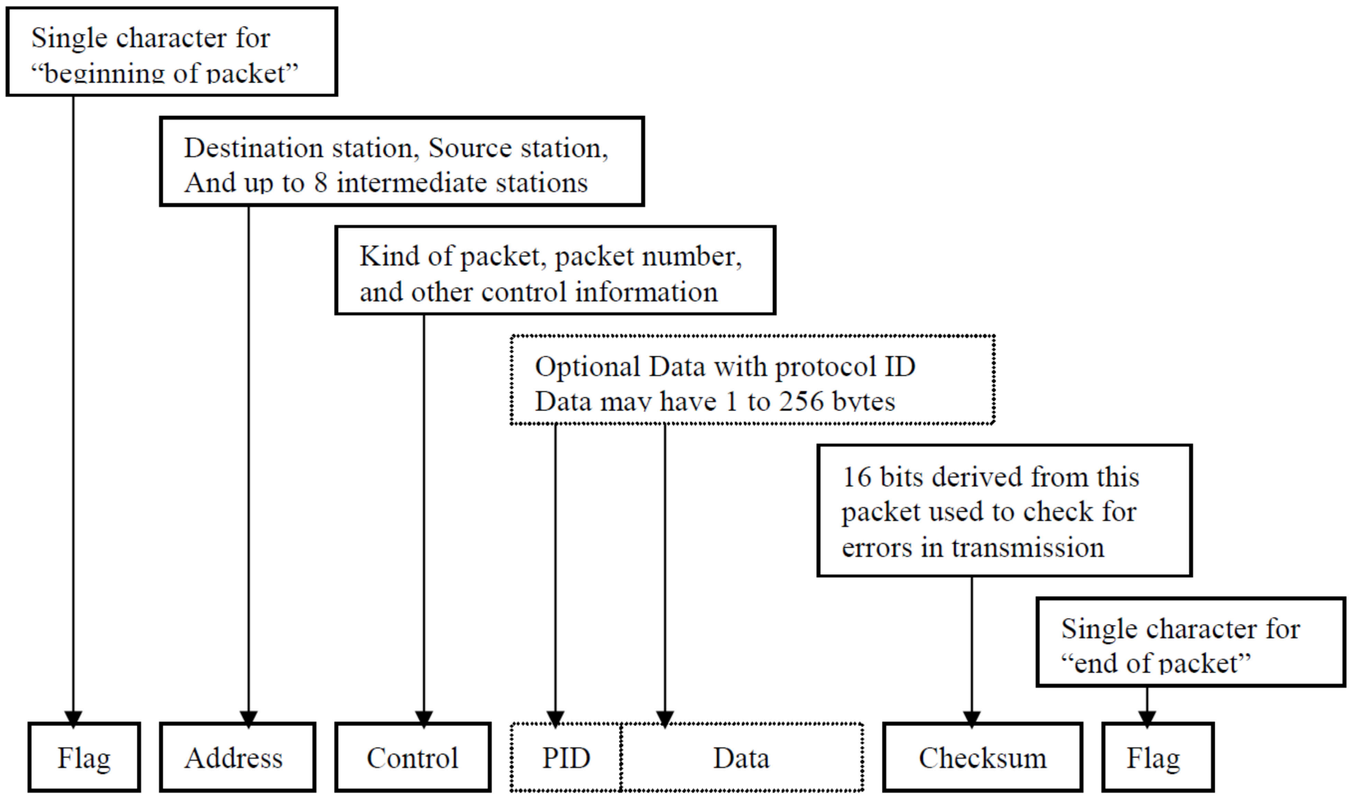
Terminal Node Controller

TNC for short

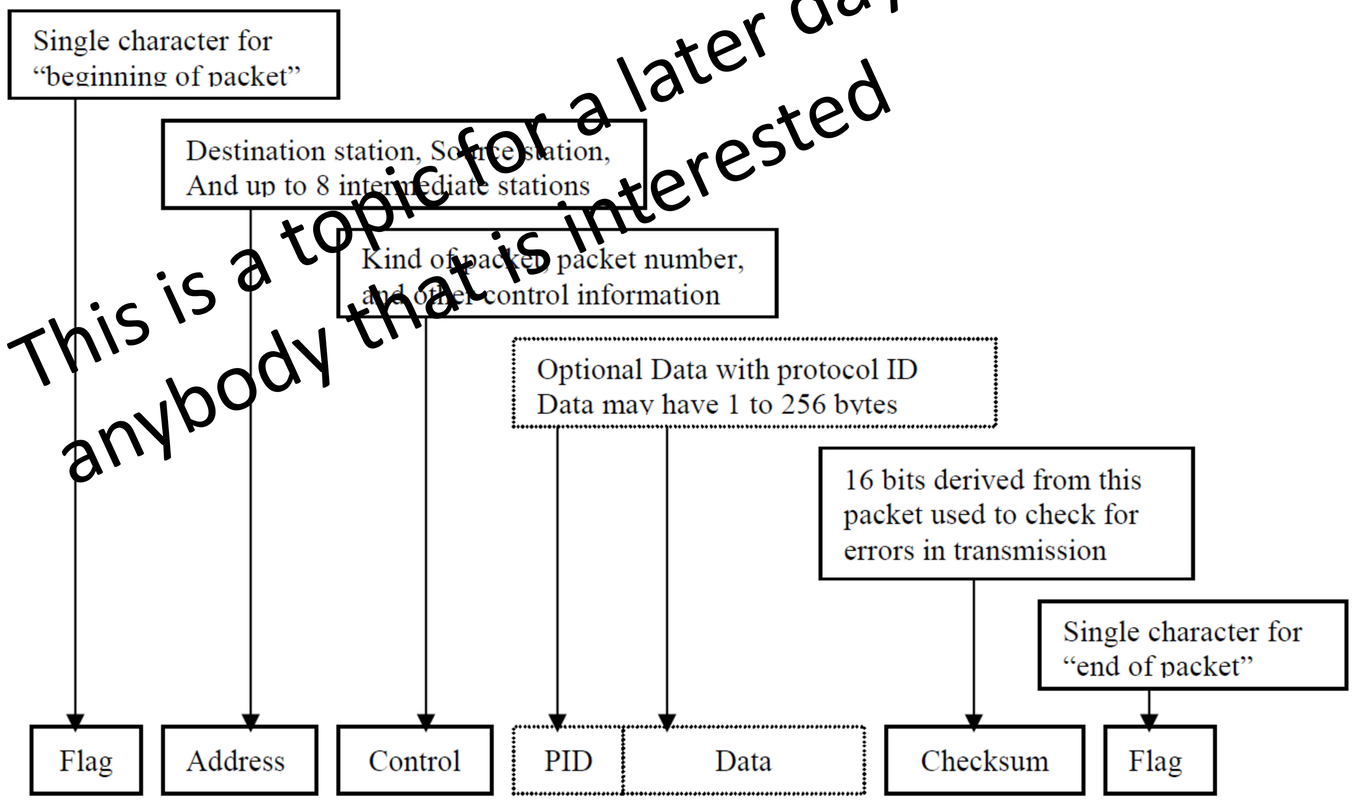
Terminal Node Controller

- A TNC takes raw digital data such as characters in an e-mail message
  - divides the characters in an e-mail message into small segments,
  - converts the character to binary 8 bit bytes
  - adds some extra bits of information (no pun intended) to provide an error checking / detecting / correcting scheme, and puts those into “packets” data
  - then converts those packets, bit by bit, into audio tones

Details on Data packing



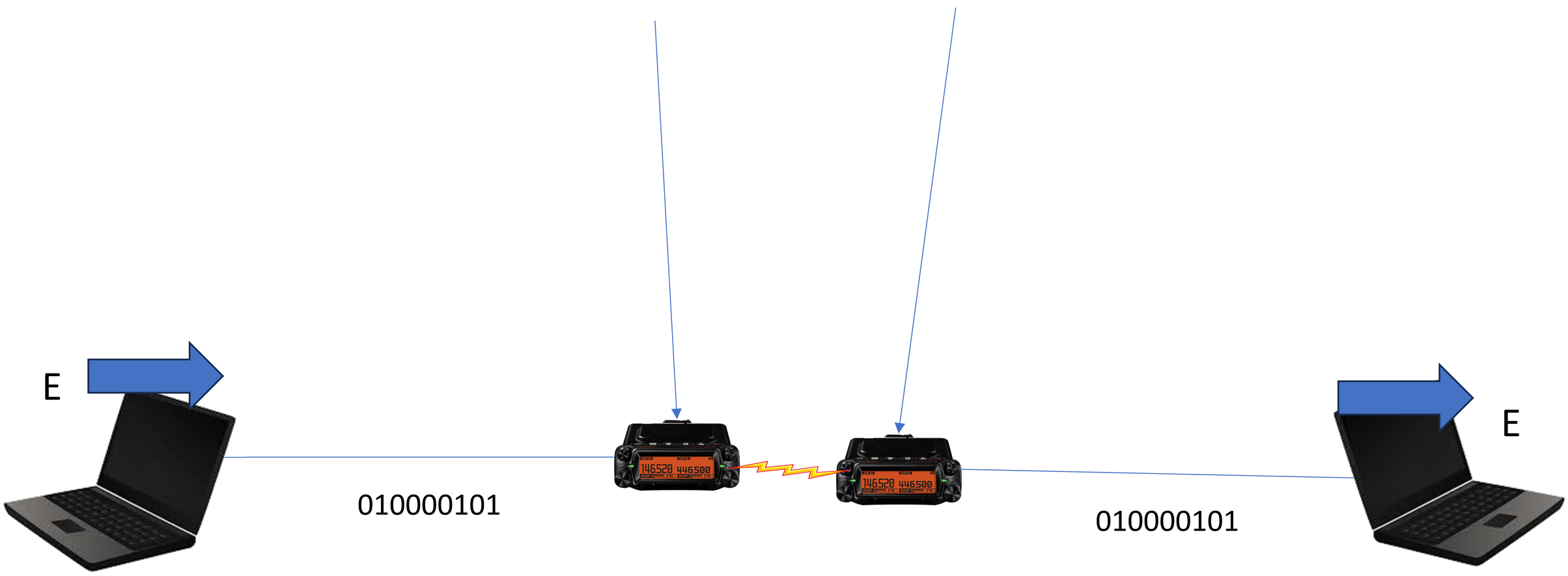
Details on Data packing



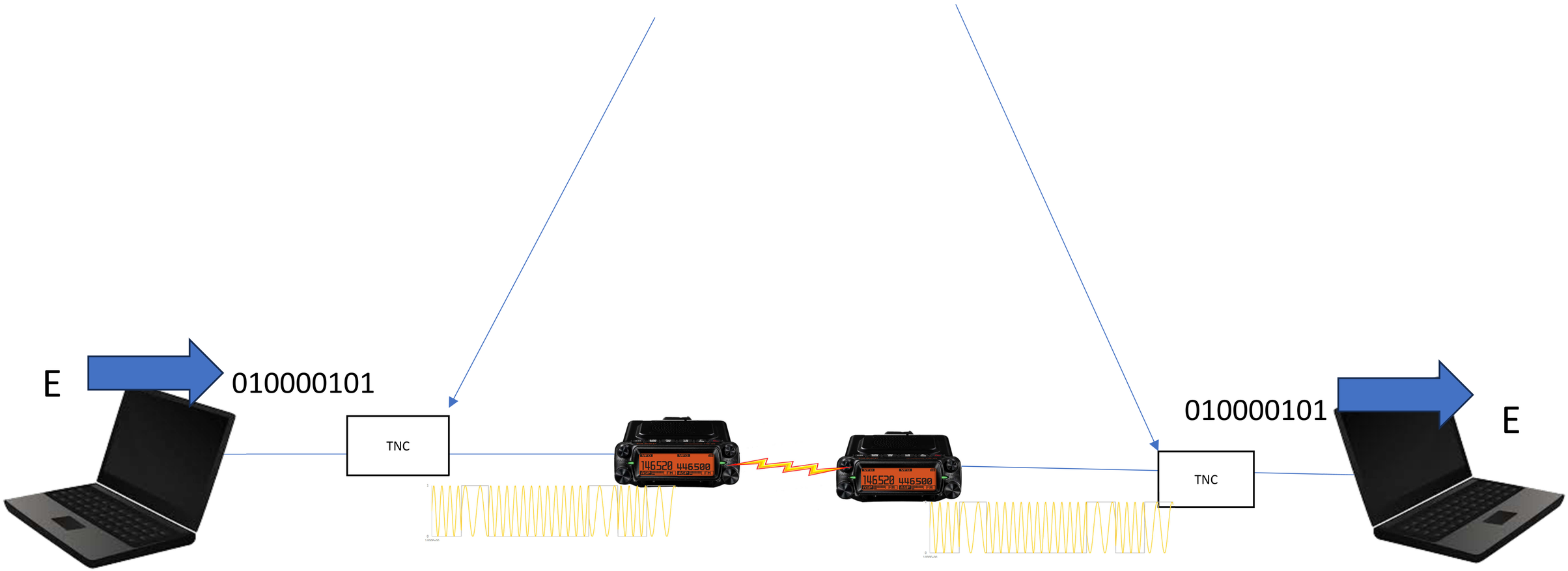
Where is the Terminal Node Controller located?

- There are multiple configurations of a combination of hardware & software that make up TNC functionality
  - Sometimes it’s built into the radio (such as the Yaesu FT-991A)
  - Sometimes it’s totally contained within an electronics box inserted between a personal computer and a radio
  - Sometimes various functions of the TNC is split between software on a personal computer and a sound card.

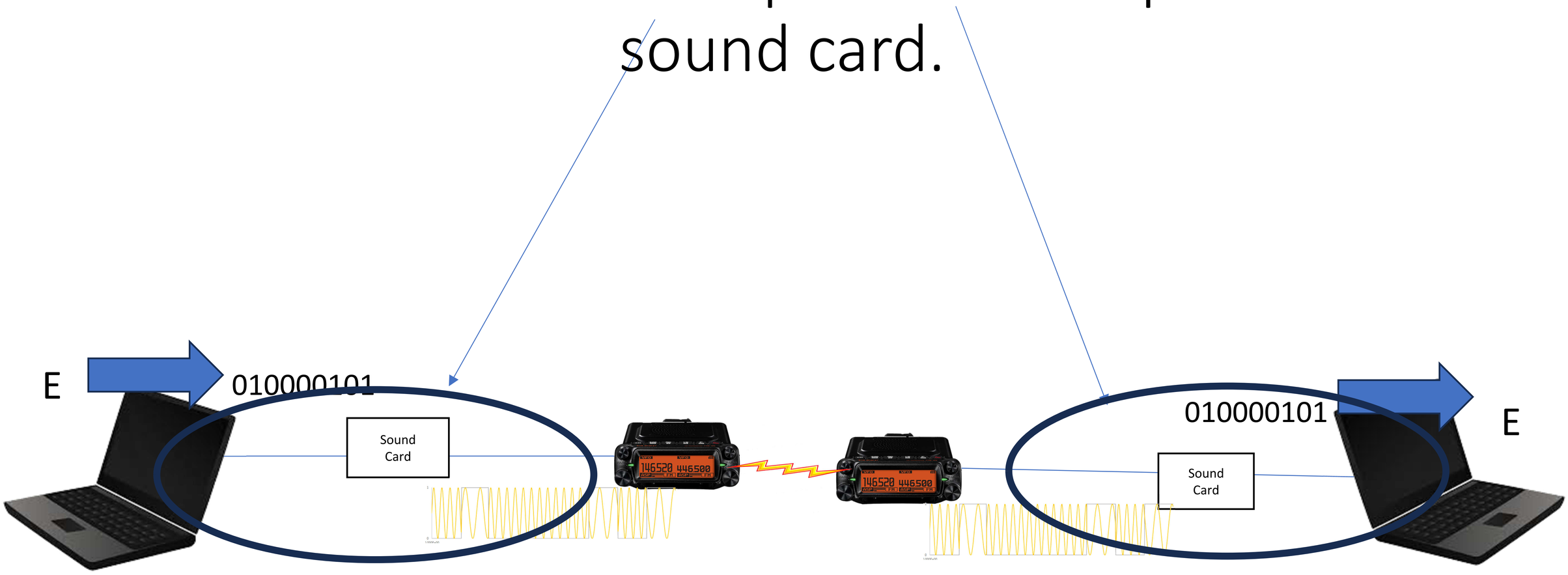
Terminal Node Controller in the radio



Terminal Node Controller in a Box



A Terminal Node Controller TNC that is split between software on a personal computer and a sound card.

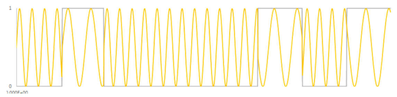


Hardware Example with specific products for

the third configuration where the TNC functionality is split between software on a personal computer and a sound card.

Example Client Hardware Set up

010000101

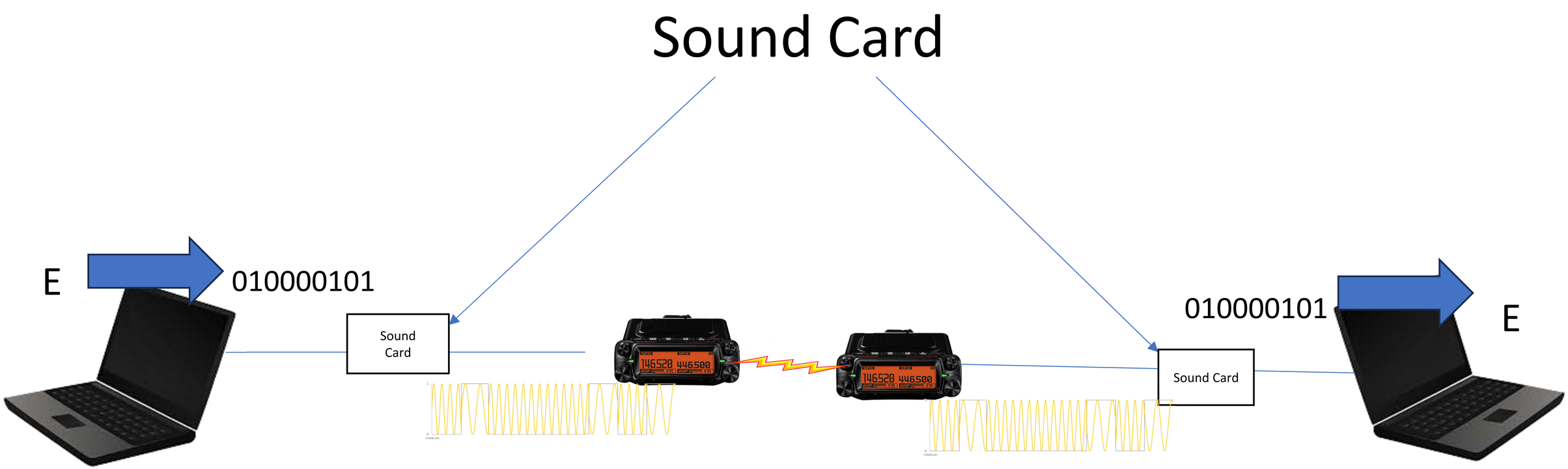


Radio Networking Architectures

Radio Mail Networking Architectures

- Peer To Peer
- Mail Server
- Gateway
- Telnet

Peer to Peer Topology

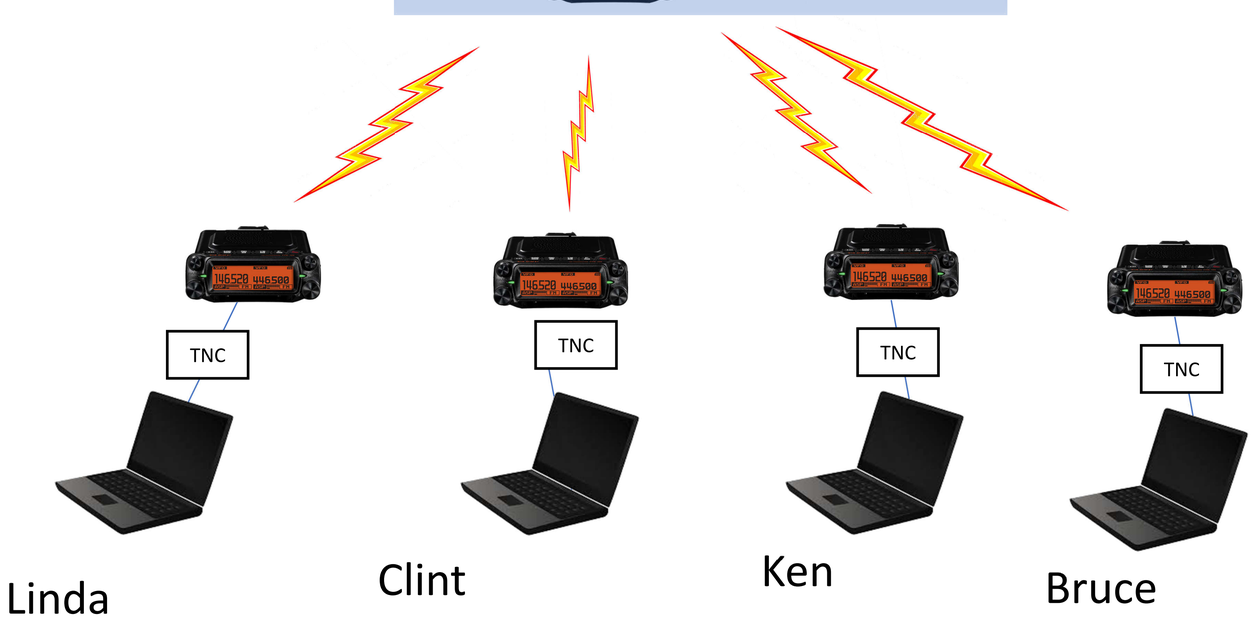


Message Server

Peer To Peer Limitations

- Advantages
  - Simplest architecture
- Limitations
  - Can only send an email to one station at a time
  - Both station operators are required to be operating their stations at the same time in order to send a message

Radio Mail Server Architecture

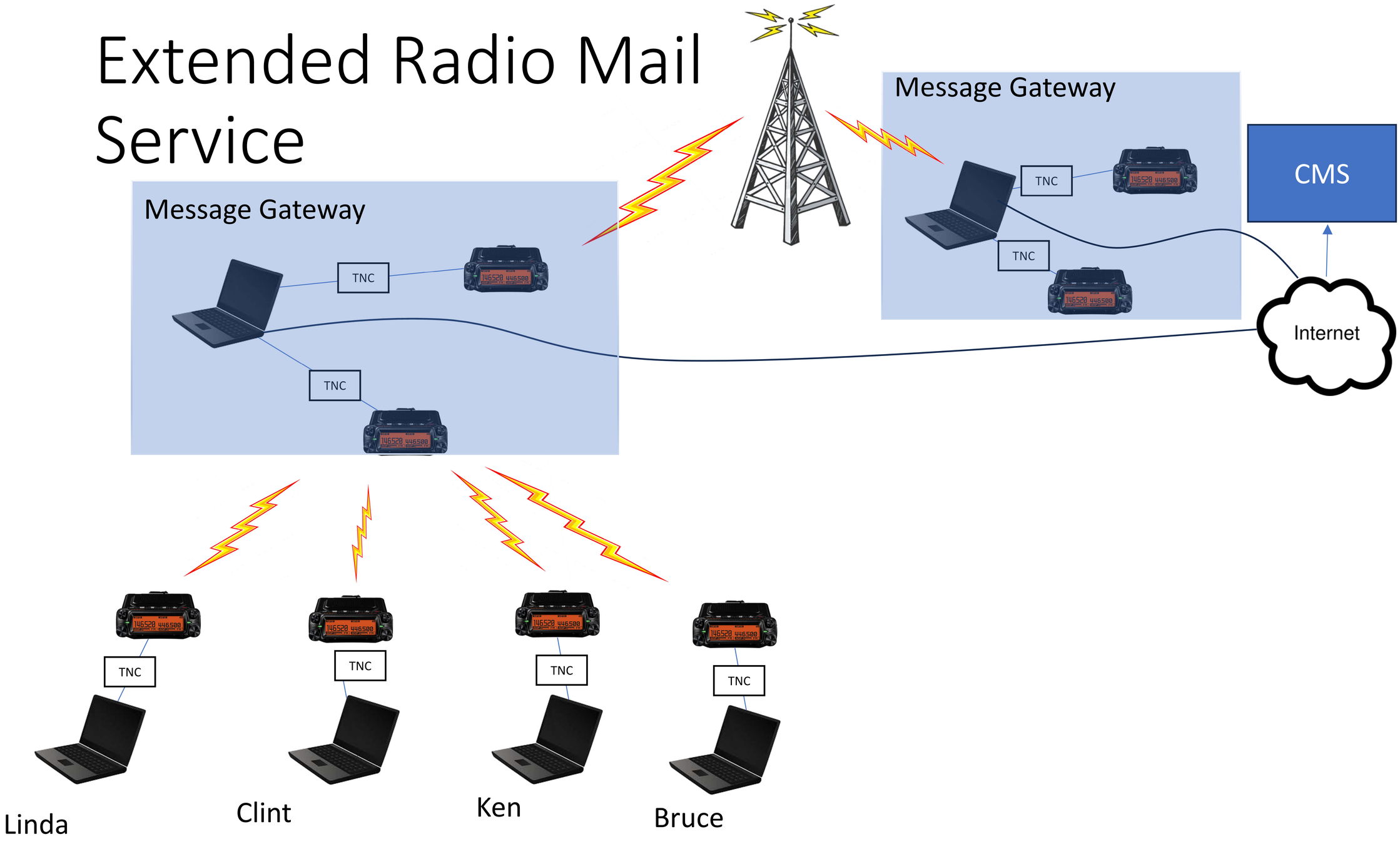


Mail is sent to the Local Radio Mail Server and stored until it is picked up by destination address

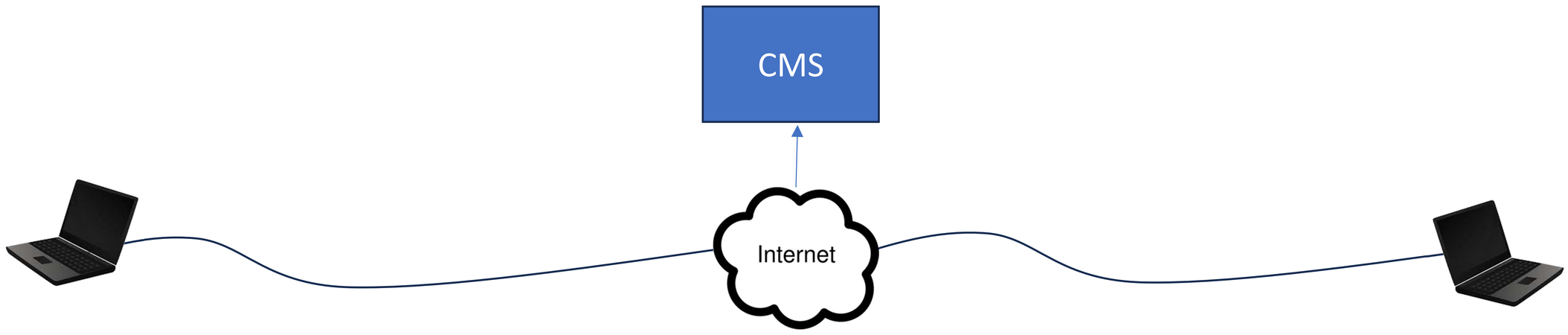
Ability to send one message to multiple stations

Gateway
Expanded Radio Mail Server
Network

Extended Radio Mail Service



Telnet Architecture



Next Session Preview

Next Session Preview

- Hands-on Workshop
  - Install Software
  - Connect computer to radio through supporting equipment
  - Learn how to use Software

  - Send and Receive Mail 

Recommended Equipment For Next Session

- Radio without built in sound card nor TNC
  - VHF and/or UHF mobile or base station
    - Use of handheld transceivers is possible but not recommended to start with
- Computer
  - Windows 10 or later operating system
    - With at least 3 USB ports
- Sound card
  - TigerTronics Signalink™ USB
    - https://tigertronics.shop/shop/ols/categories/signalink-usb
- Cables
  - USB Cable from computer to SignaLink™ sound card
    - Provided in the with the SignaLink™ sound card
  - Cable from the sound card to the radio
    - This cable type & make is dependent on the radio
      - TigerTronics has a list of cables for popular radios in the .pdf file called "SignaLink USB Product Guide"
      - Note to Bruce: Print out Product Guide
      - Web link is : https://tigertronics.com/files/SignaLink%20USB%20Product%20Guide.pdf

- Radio with built in sound card / TNC
  - VHF and/or UHF mobile or base station
    - Use of handheld transceivers is possible but not recommended to start with
- Computer
  - Windows 10 or later operating system
    - With at least 3 USB ports
- Cables
  - Need the correct cable that goes from the computer USB port to the RADIO's TNC or data port