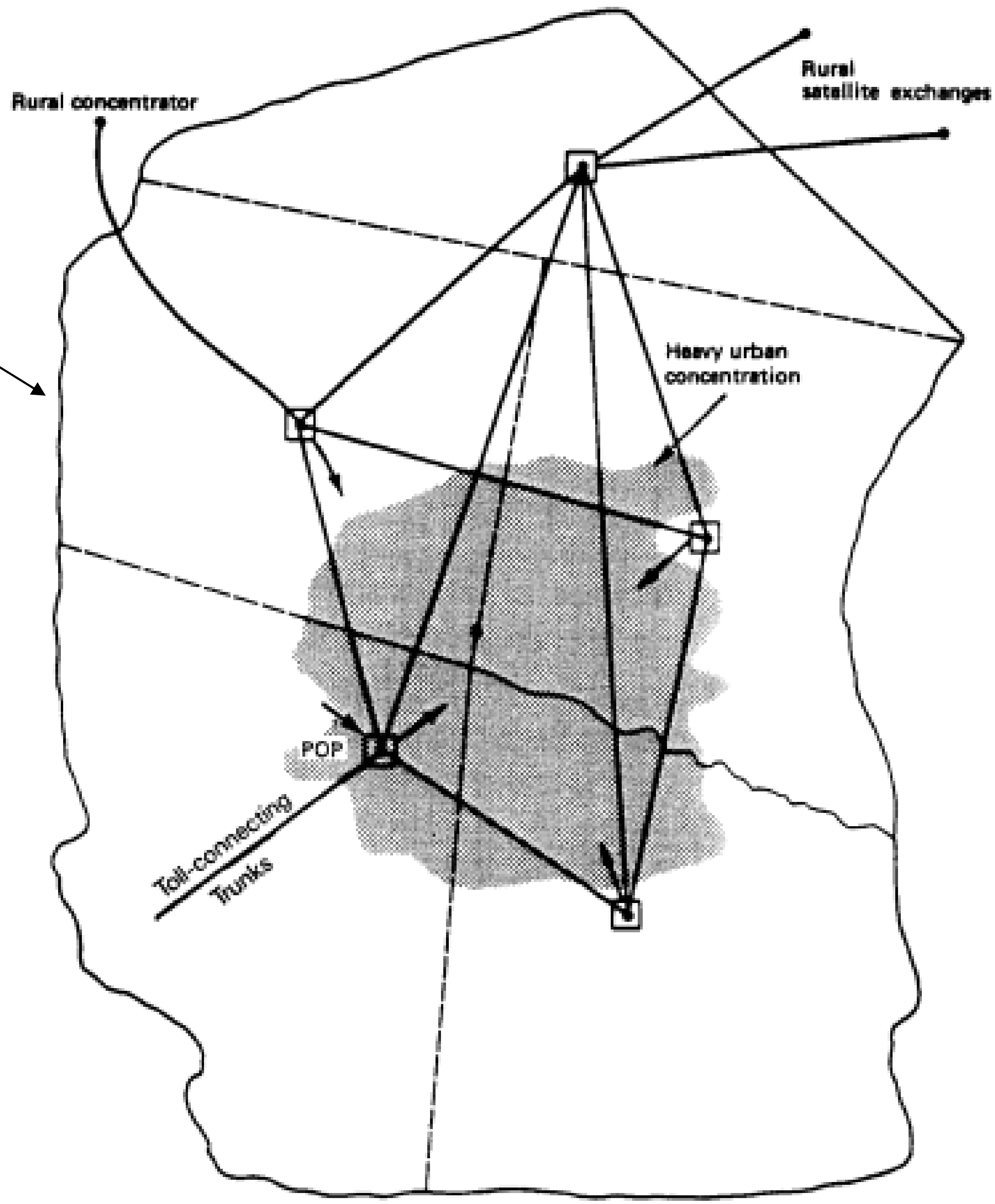
Chapter 2

Local Networks

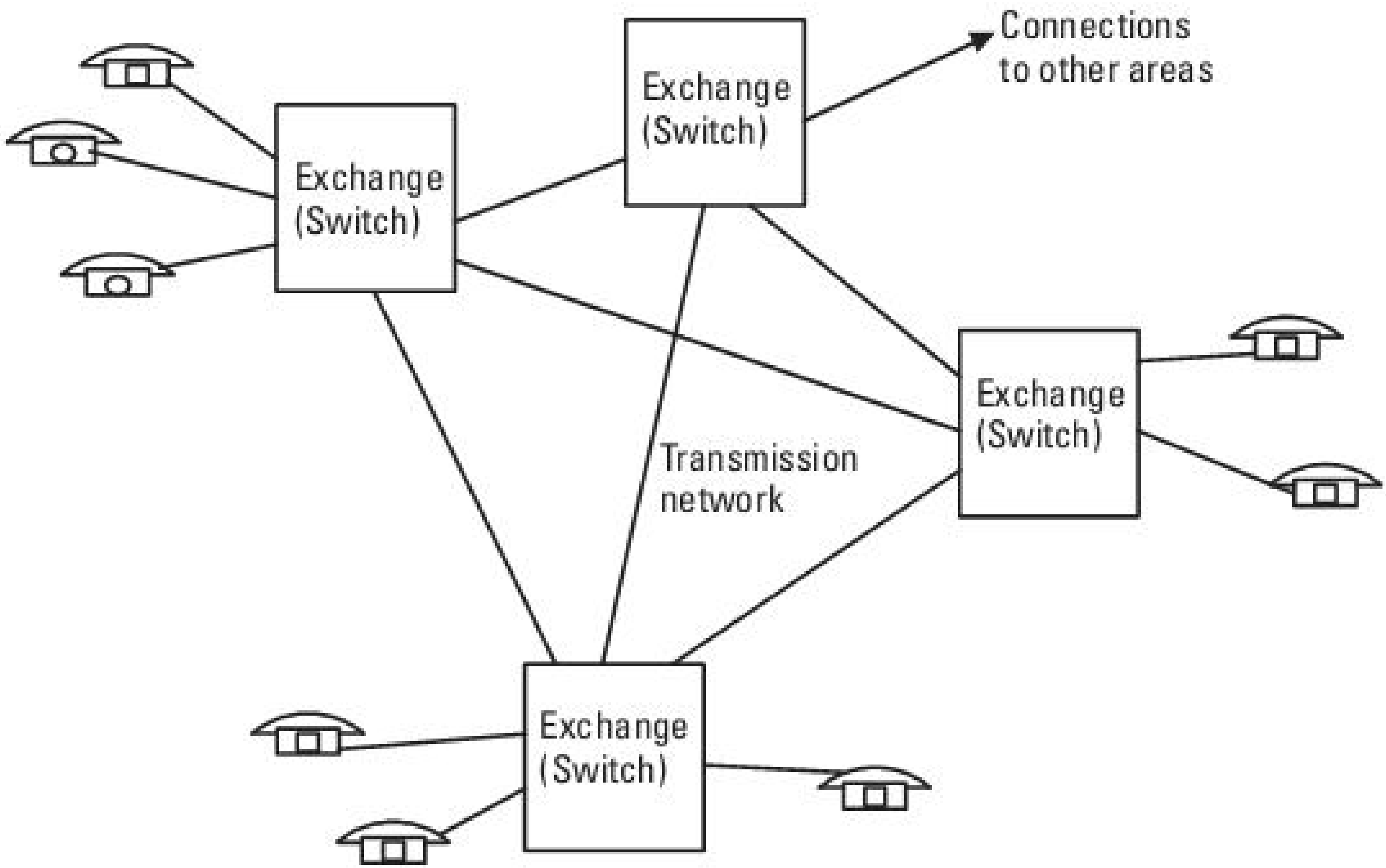
1 Introduction

- The Local Area includes:
  1. The subscriber plant.
  2. The local exchanges.
  3. The trunk plant interconnecting these exchanges.
  4. Trunks connecting a local area to the next level of network hierarchy, or the point of presence (POP).

Geographical area of five exchanges



A sample local area (arrows represent trunk pull; dashed lines delineate serving areas).



Basic Telecommunication Network

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- To **build** the most **economical** local network assuming an **established Quality of Service (QoS)**, the following should be known:

1. Geographic extension of the local area of interest.
2. Number of inhabitants and existing telephone density.
3. Calling habits.

Continue…

4. Percentage of business telephones.
5. Location of existing telephone exchanges and extension of their serving areas.
6. Trunking scheme.
7. Present signaling and transmission characteristics.

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We will assume that

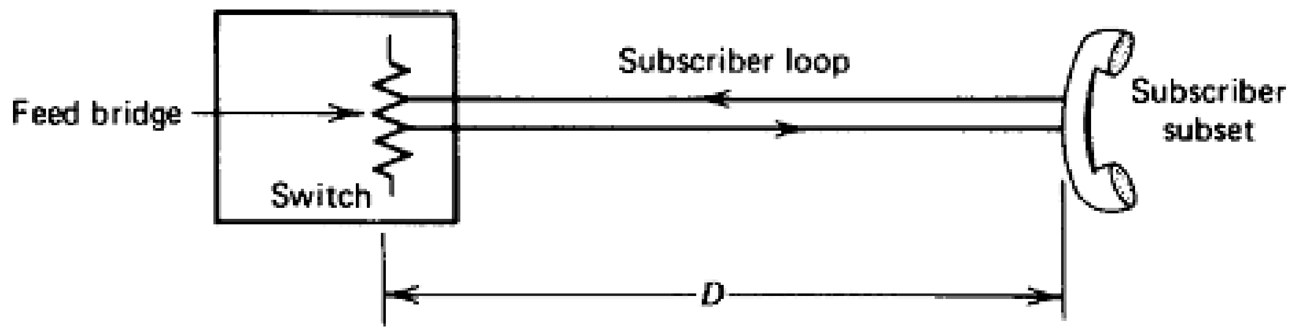
- Each exchange in the sample will be capable of serving up to **10,000** subscribers.
- All telephones in the area have **seven-digit numbers**, the last four of which are the subscriber number of the respective serving area of each exchange.
- All subscribers are connected to their respective serving exchanges by wire pairs, resulting in some limiting **subscriber loop length**.

2 Subscriber Loop Design

- It is a **dc loop** in that it is a wire pair supplying a metallic path for the following:

1. Talk battery for the telephone transmitter.
2. An AC ringing voltage for the bell.
3. Current to flow through the loop when the telephone instrument is taken out of its cradle ("off hook"), telling the serving switch that it requires "access," thus causing a line seizure at that switch.
4. Dialing tones indicating the desired party.

2.3 Local Loop Design Techniques



- The loop length *D* is a critical parameter.
- The greater the value of *D*, the greater the attenuation that the loop suffers.
- Likewise, there is a limit to *D* due to dc resistance.
- Also, the greater the wire diameter of the loop pair, the less resistance there is per unit length.

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- When we lift the telephone off hook, there must be enough current flow in the loop to actuate the local switch where the loop terminates.
- The high impedance voltage of the line is -48 V dc.
- The question is, when designing a subscriber loop, what its maximum length D would be?

Continue…

- There are two variables that must be established:

1. The maximum loop resistance: this value is a function of the switch circuit where the loop terminates and its value is **1000 Ω** (**old**) or **2400 Ω** (**new**)
2. The maximum loss or attenuation on the loop: In Europe it is **6 dB at 800 Hz**, and in North America it is **9 dB at 1000 Hz**.

- When budgeting a value for the loop, we should budget some value to the telephone set, **300 Ω** has been assigned.

2.3.2 Calculating the Resistance

- For copper conductor, the DC loop resistance is calculated as follow:

$$R_{dc} = \frac{0.1095}{d^2}$$

Where $\boldsymbol{R_{dc}}$ is the loop resistance in ohms per mile and $\boldsymbol{d}$ is the diameter of the conductor in inches.

Continue…

- **Example**: we wish a 10-mile loop and allow 100 Ω per mile of loop, what diameter of copper wire would be needed?

$$100 = \frac{0.1095}{d^2}$$

$$d^2 = \frac{0.1095}{100}$$

$$d = 0.033 \text{ in. or } 0.76 \text{ mm (round off to } 0.80 \text{ mm)}$$

1 mile = 1.60934 km
1 inch = 25.4 mm

Hence, for 100 Ω per mile loop resistance, the diameter of the loop should be 0.80 mm

Continue…

TABLE 2.4 Loss and Resistance per 1000 ft of Subscriber Cable[a] [8]

Cable Gauge AWG	Cable Diameter (mm)	Loss per 1000 ft (dB) @1000 Hz	Loss per Kilometer (dB) @ 1000 Hz	Loop Resistance (Ω/1000 ft)	Loop Resistance (Ω/km)
28	0.32	0.666	2.03	142	433
26	0.405	0.51	1.61	83.5	270
24	0.511	0.41	1.27	51.9	170
22	0.644	0.32	1.01	32.4	107
19	0.91	0.21	0.71	16.1	53

Using Table 2.4, we can compute maximum loop lengths for 1000 Ω signaling resistance. Use a 26-gauge loop. We then have

$$\frac{1000}{83.5} = 11.97 \text{ kilofeet or } 11{,}970 \text{ ft}$$

Continue…

Let's use the **2400 Ω** switch as another example. Subtract **300 Ω** for the telephone subset, leaving us with a net of **2100 Ω**. We will use a **26-gauge** wire pair on the loop, then from Table 2.4 we have

$$\frac{2100}{83.5} = 25.149 \text{ kft or } 25{,}149 \text{ ft}$$

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If we are limited to **6 dB loss** on a subscriber loop, and we know the loss per **1000 ft** for different AWG, then we can calculate the length of the subscriber loop for different AWG as follow

$$28 \qquad \frac{6}{0.666} = 9.0 \text{ kft}$$

$$26 \qquad \frac{6}{0.51} = 11.7 \text{ kft}$$

2.3.4 Loading

- In some cases it is desirable to extend subscriber loop lengths beyond the limits described previously.
- Common methods to attain longer loops without exceeding loss limits are

1. **Increase conductor diameter (AWG).**
2. **Use amplifiers or range extender.**
3. **Inductive loading.**

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- **Loading** a particular voice-pair loop consists of **inserting inductances** in series (**loading coils**) into the loop at fixed intervals.
- Inductive loading tends to:

1. Reduce transmission loss on the subscriber (i.e. better frequency response)
2. Decrease the velocity of propagation and **increase the impedance**.

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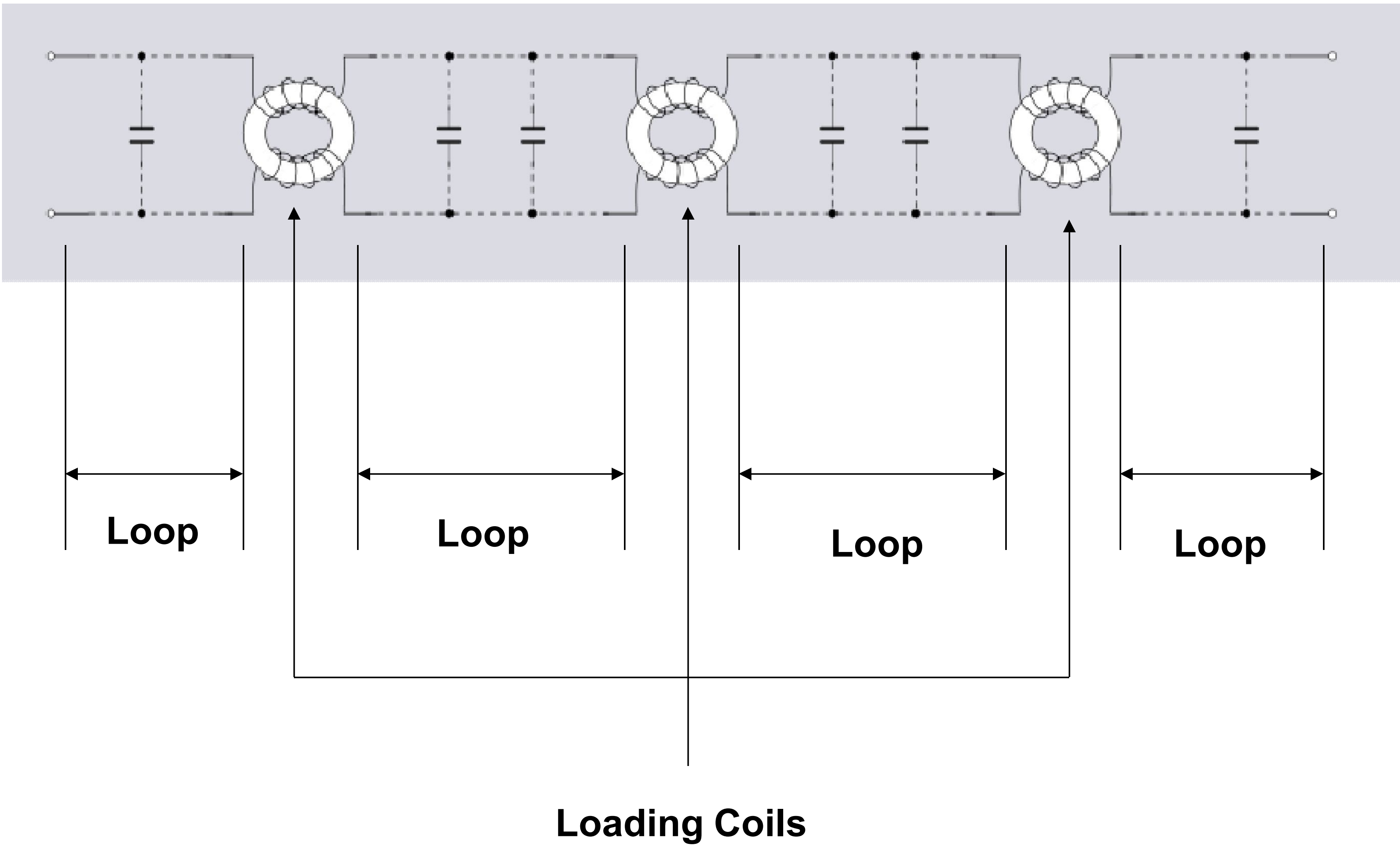

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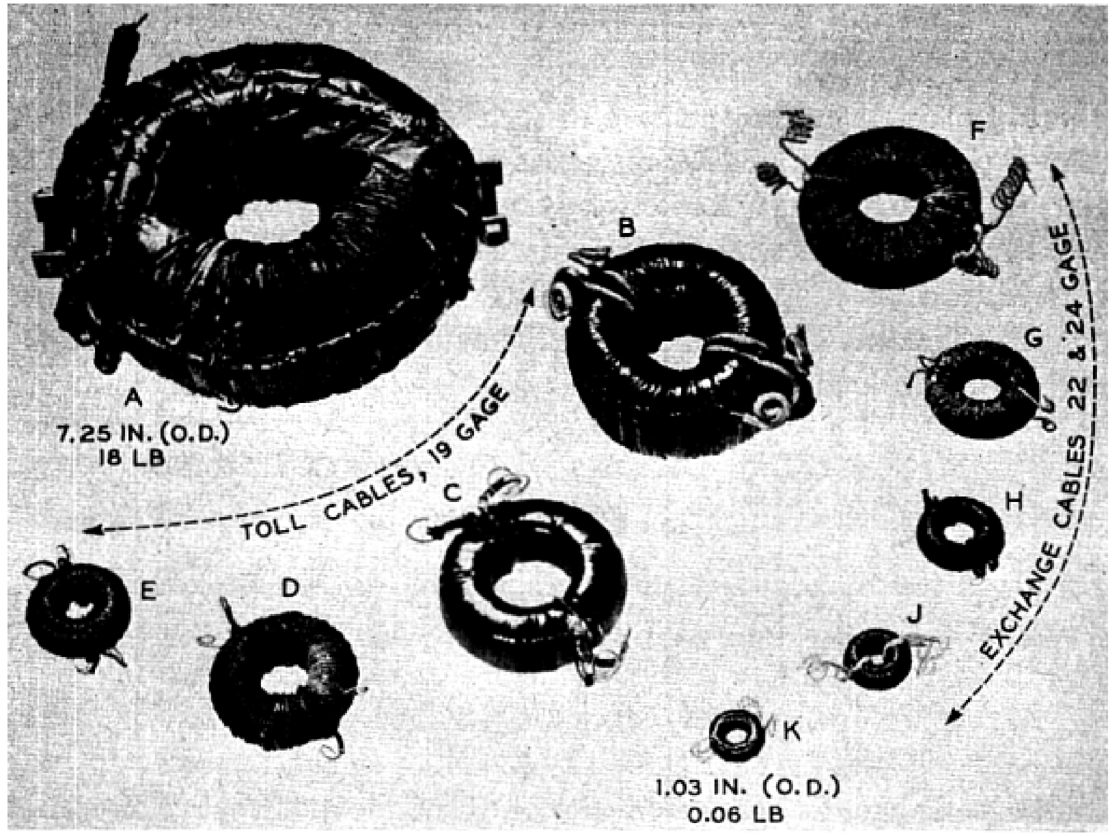
TABLE 2.5 Code for Load Coil Spacing [2, 8]

Code Letter	Spacing (ft)	Spacing (m)
A	700	213.5
B	3000	915.0
C	929	283.3
D	4500	1372.5
E	5575	1700.4
F	2787	850.0
H	6000	1830.0
X	680	207.4
Y	2130	649.6



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- Loaded cables are coded according to the spacing of the load coils.
- Loaded cables are typically designated 19-H-44, 24-B-88, and so forth.
- **Example: 19-H-44 means**

1. **19 = AWG**
2. **H = 6000 ft spacing.**
3. **88 = Inductance in mH (88 mH)**

4.1 Exchange Area

- The size of an **Exchange Area** is also called a **Serving Area**.
- It obviously will depend largely on

1) **Subscriber density.**
2) **Subscriber distribution.**
3) **Subscriber traffic.**

4.2 Exchange Size

- Exchange sizes are often in units of **10,000 lines**.
- **10,000** is the number of subscribers that may be connected when an exchange reaches "**exhaust**," where it is filled and no more subscribers can be connected.
- The number of subscribers initially connected should be considerably smaller than when an exchange is installed.

5 Shape of Serving Area

- It has a considerable effect on **optimum exchange size**.
- If a serving area has sharply angular contours, the exchange size may have to be reduced to avoid excessively long loops.
- In other words, more exchanges must be installed in a given local geographical area of coverage.

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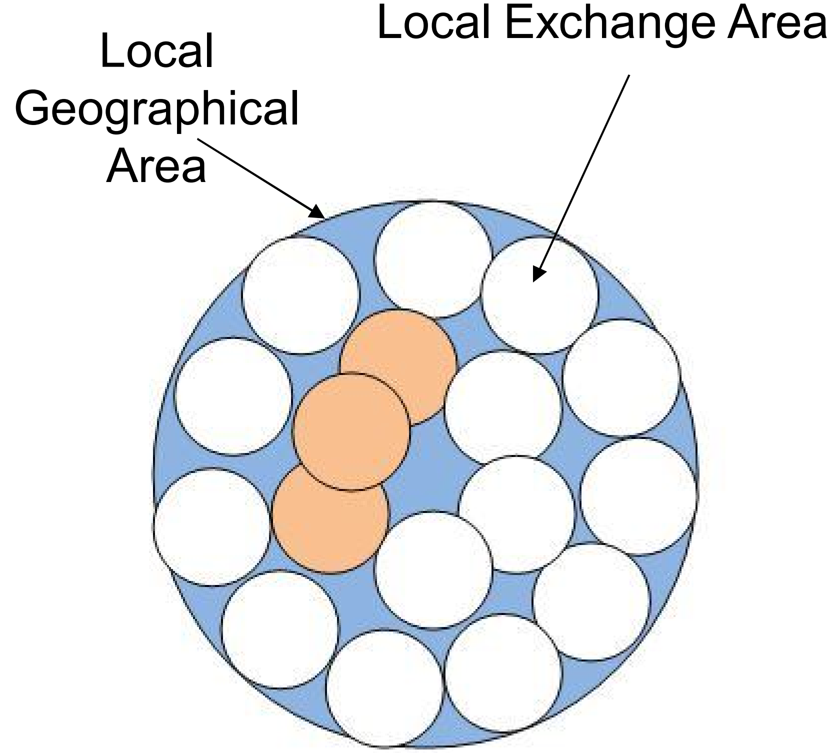
- Fully circular exchange serving areas are impractical because either the circles will overlap or uncovered spaces will result.



Circular coverage area

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- There are then two possibilities: square or hexagonal serving areas.
- Of the two, a hexagon more nearly approaches a circle.
- The size of the hexagon can vary with density with a goal of 10,000 lines per exchange as the ultimate capacity.
- Full coverage of local areas may only be accomplished using serving areas of equal triangles or squares.

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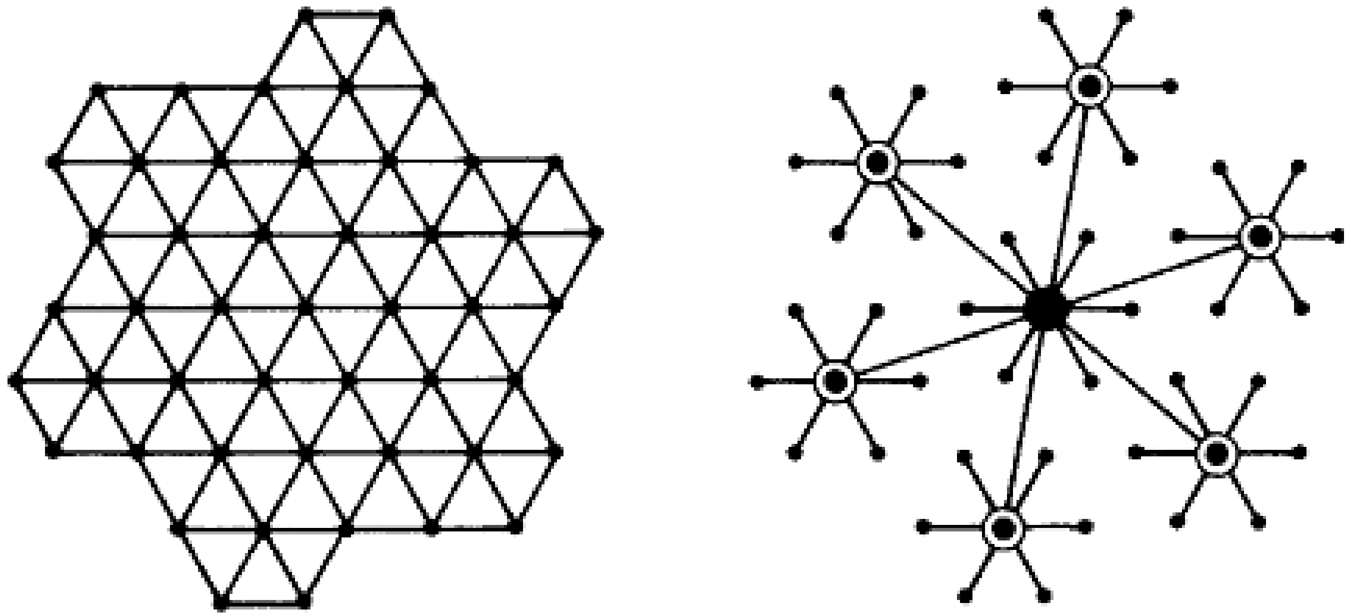

Hexagonal serving area and interconnection of exchanges