

# Radio over IP

## A Technician's Guide to the Technology

2008 APCO Summer  
Training Conference  
Wenatchee, WA

# What's with all this RoIP Stuff?

- How to keep from being at the end of your RoIP
- Avoiding enough RoIP to hang yourself
- RoIP, VoIP this all makes me feel like a DoIP



# What is RoIP?

- RoIP = Radio over Internet Protocol
- VoIP = Voice over Internet Protocol
- RoIP  $\neq$  VoIP but there are similarities
- More alphabet soup –
  - TCP/IP
  - UDP/IP

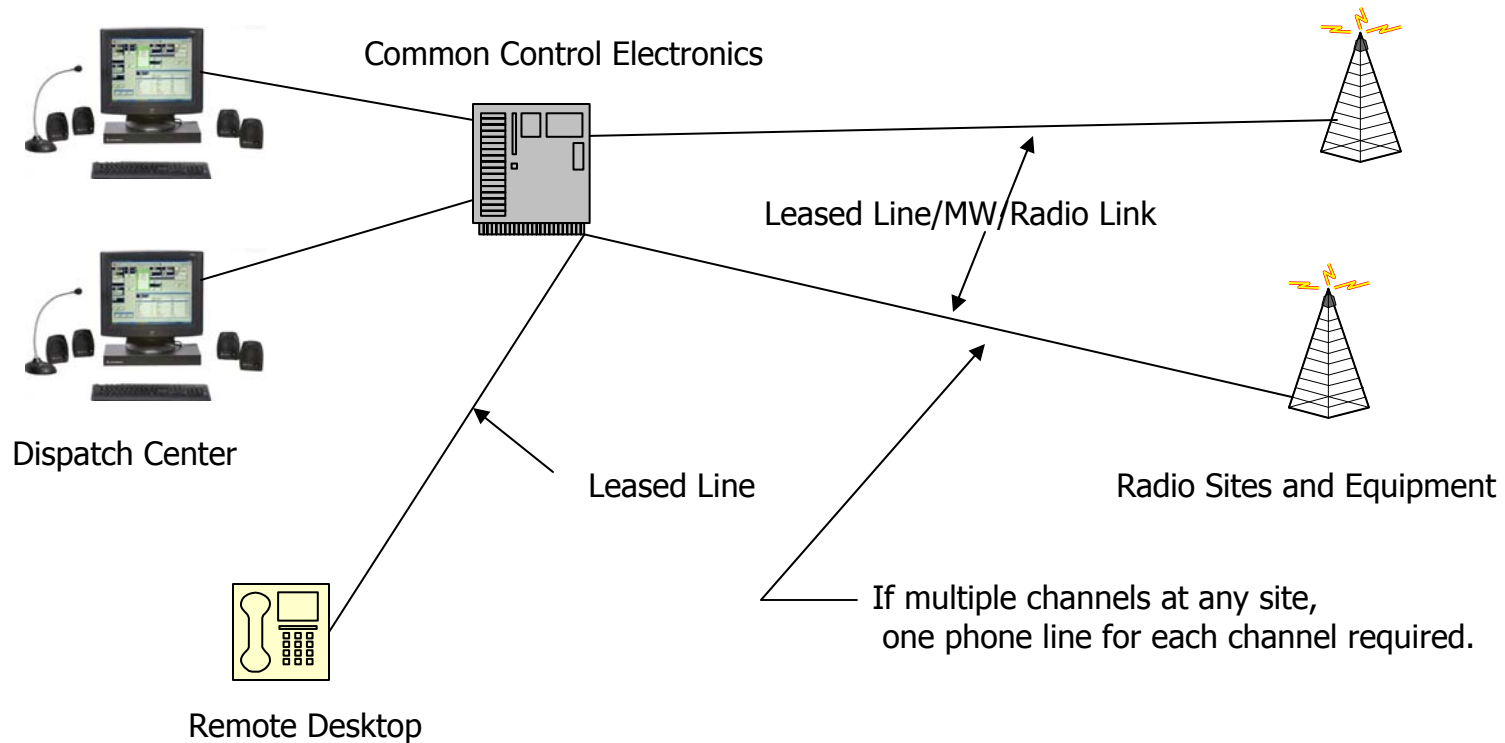


# What is RoIP?

- It is a method of interconnecting consoles, radios, telephones, and other devices
- It is not transmitted over-the-air to the user radios
- RoIP ≠ P25
- Uses standard Internet Protocols (IP)
  - TCP/IP – Most reliable format because provides guaranteed delivery but not generally used for voice because of bandwidth
  - UDP/IP – Uses less bandwidth but may be less reliable because no guaranteed delivery
  - Uses many of the standards and protocols available in most data networks but not necessarily allowed by the network manager

# Why RoIP?

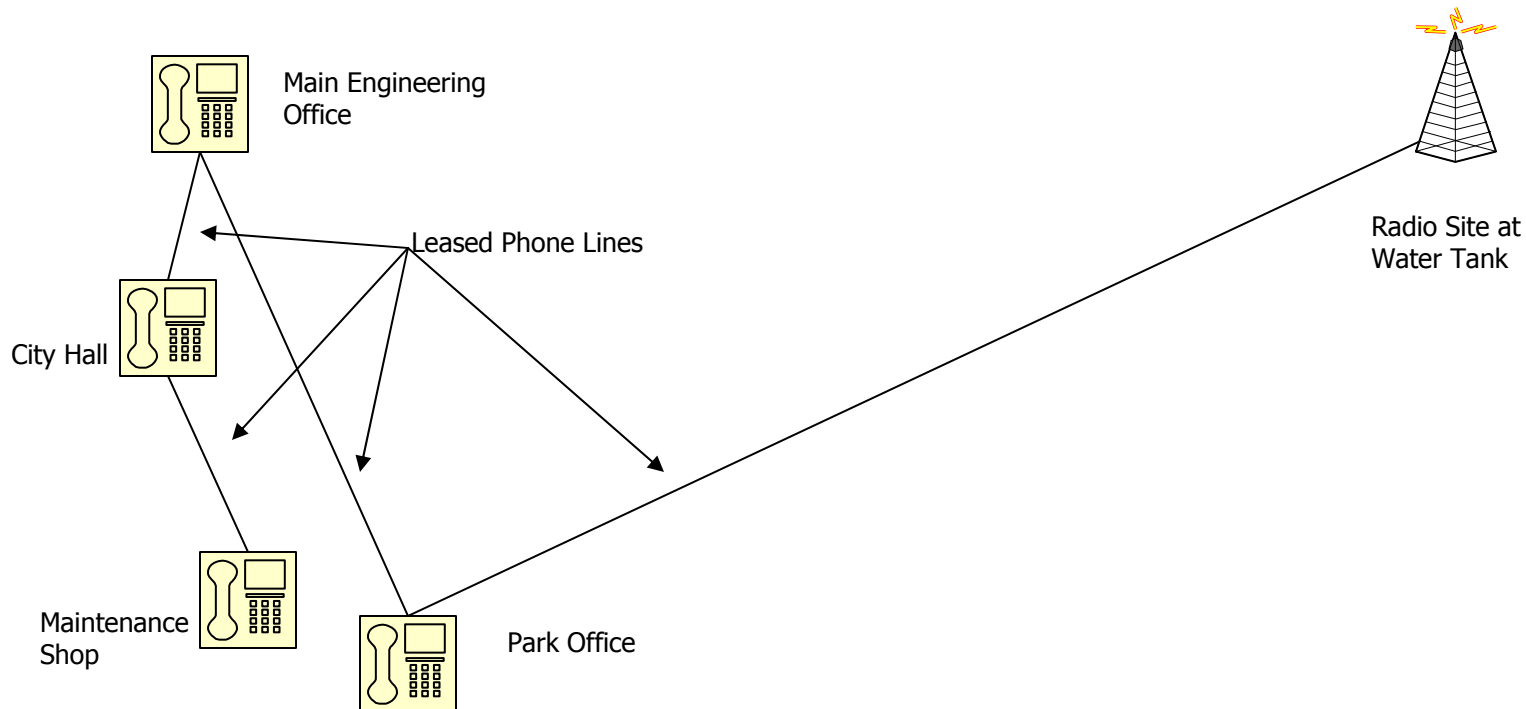
## ■ Typical radio network today



# Why RoIP?

## ■ Another example

Public Works Radio System

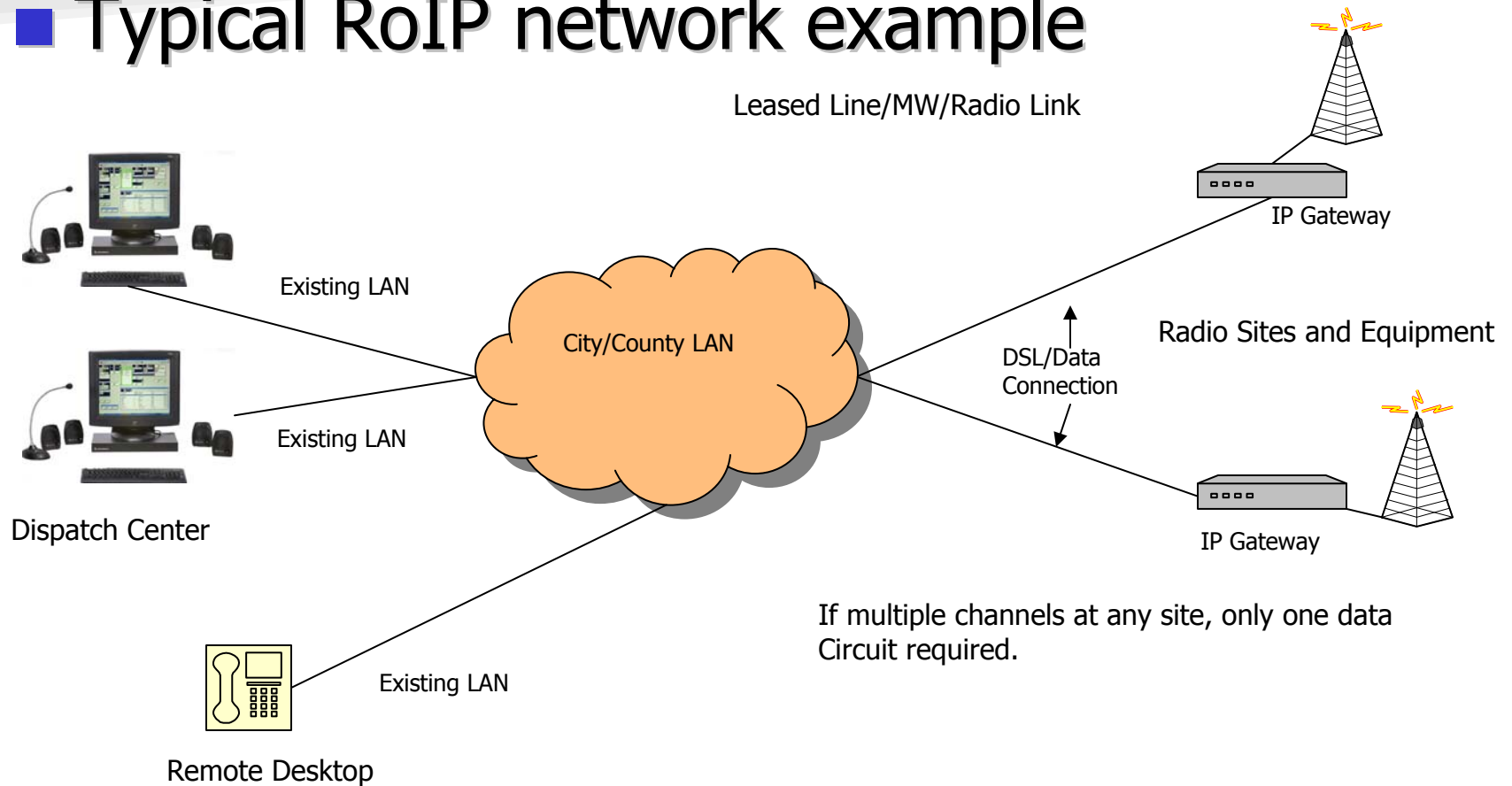


# Why RoIP?

- What do those examples have in common?
  - Use of dedicated phone lines or other interconnection method for each site/channel
  - Use of dedicated phone lines to interconnect remote console positions
  - High on-going costs for dedicated facilities
  - Loss of one connection point could cause loss of communications
  - Dedicated facilities are expensive

# Why RoIP?

## ■ Typical RoIP network example

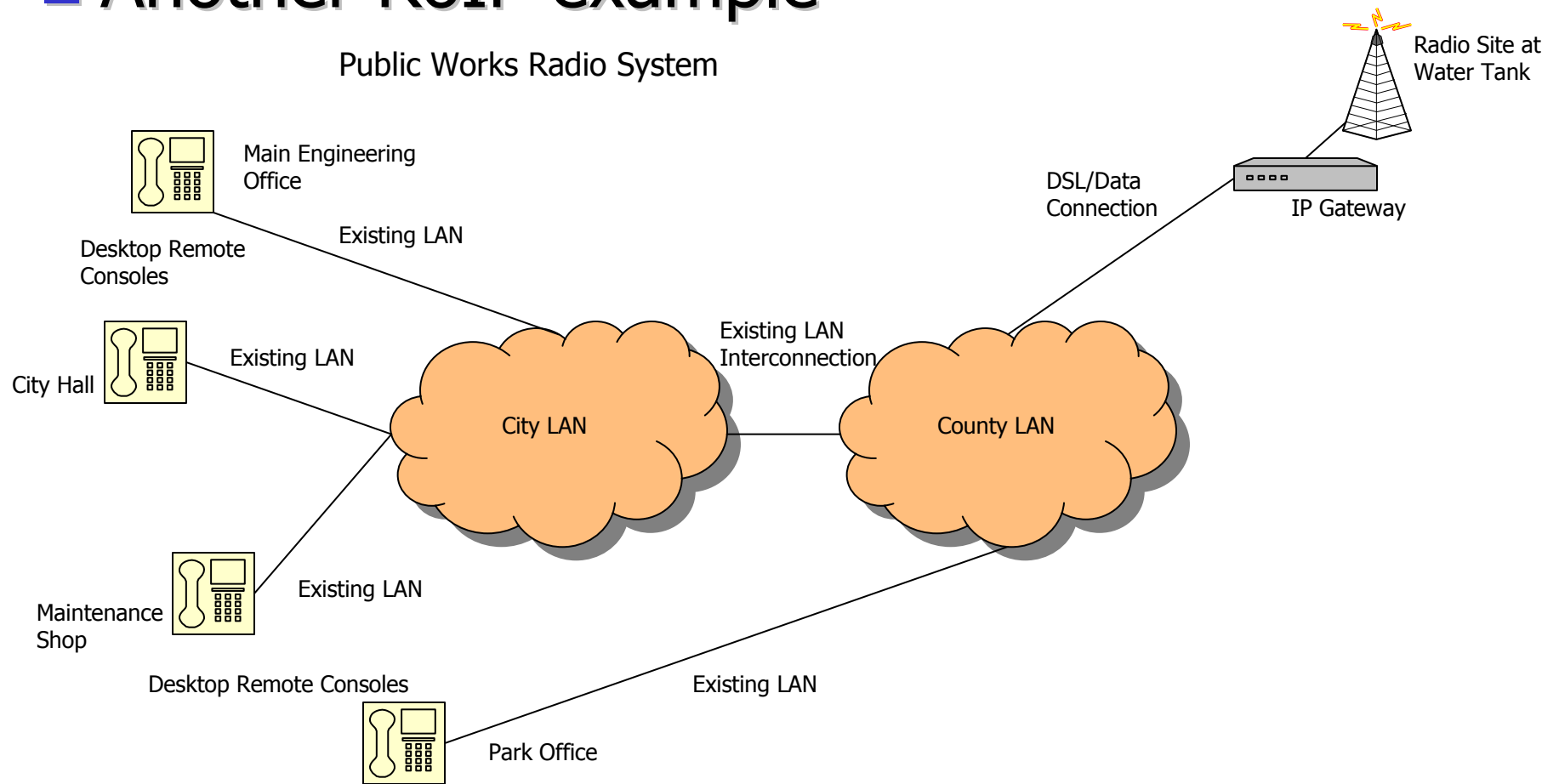




# Why RoIP?

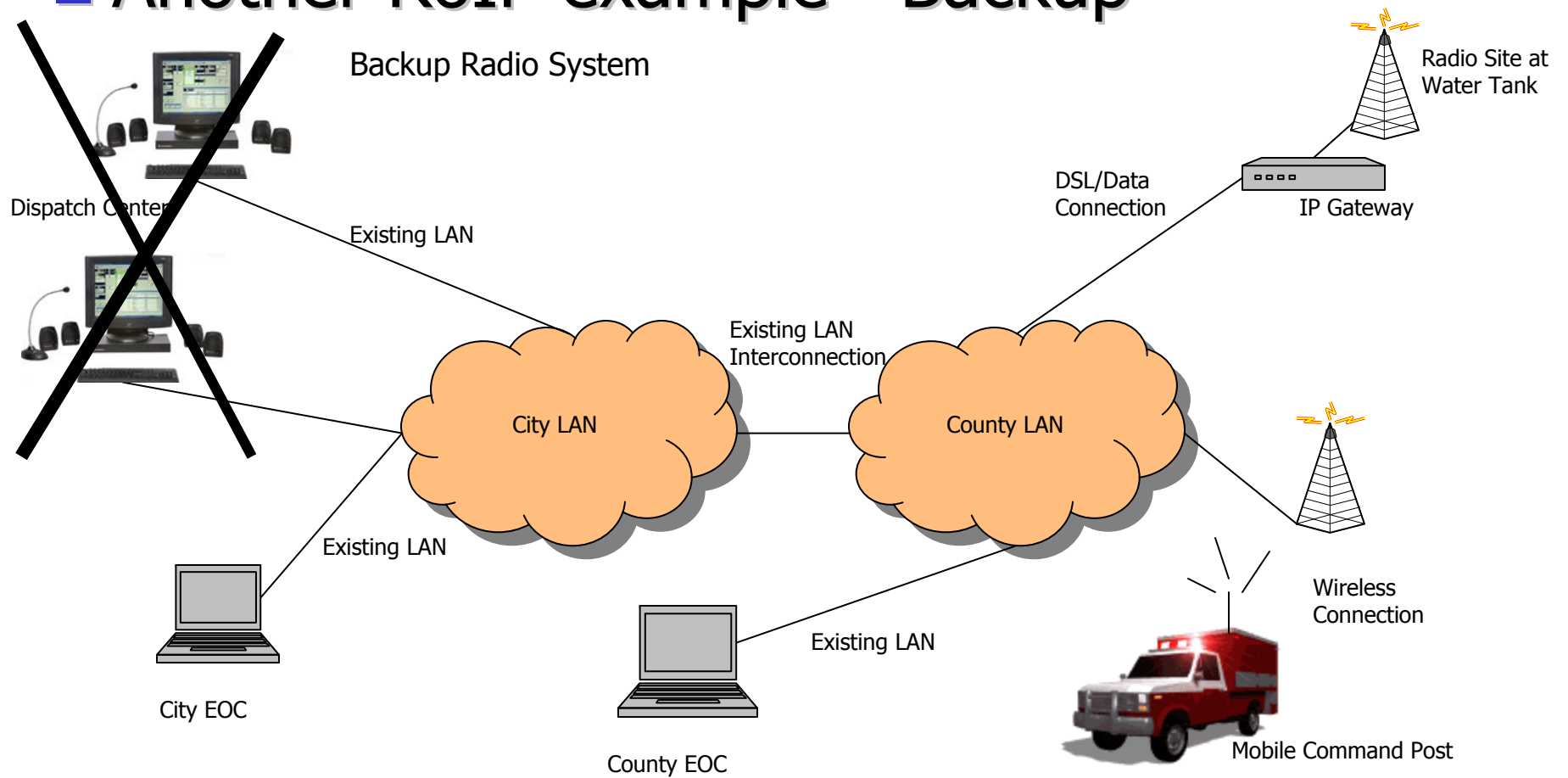
## ■ Another RoIP example

### Public Works Radio System



# Why RoIP?

## ■ Another RoIP example - Backup



# The Promise of RoIP

- Reduces costs because existing data networks can be used
- Easy to use, interconnects many different brands of equipment
- Control consoles can be located anywhere there is a data network and a simple laptop can be used
- Reduces costs because standard computer hardware can be used
- Great for disaster recovery and back up because data networks are often more resilient than voice or dedicated facilities
- Reduces costs because one data circuit can handle multiple base stations
- Interconnects many different kinds of equipment such as cell phones, 2-way radio, Nextel phones, Internet Phones, VoIP phones, etc.
- Plug and Play

# Technical Details

## ■ Data Networking

- Common use:
  - TCP/IP for control signals – More reliable
  - UDP/IP for voice data – Less bandwidth
  - Multicast – Routing data to multiple points
  - Fixed IP addresses
  - Be careful with any network assumptions as different vendors have implemented network interfaces differently.
- Quality of service is generally required to ensure delivery of audio packets. (Remember they are UDP/IP.)
- Multiple ports may need to be opened in firewalls, etc. for proper operation.
- Virtual LANs do not guarantee bandwidth.
- Network security must be managed.

# Technical Details

## ■ Radio Interface

- Interfaces often come from data world not radio world.
  - Watch voltages and current capabilities
  - Grounds and polarities can be a problem
  - May require intervening relays or interface circuits
- Audio interfaces
  - May not be standard 600 ohm balanced circuits
  - Audio levels may be different that standard
  - May require transformers or other devices
- Non-standard signaling tones may not be supported
- IP to Radio Interface (Gateway) may not be made for remote site environment.

## ■ RoIP is not standardized – Be careful

# Technical Details

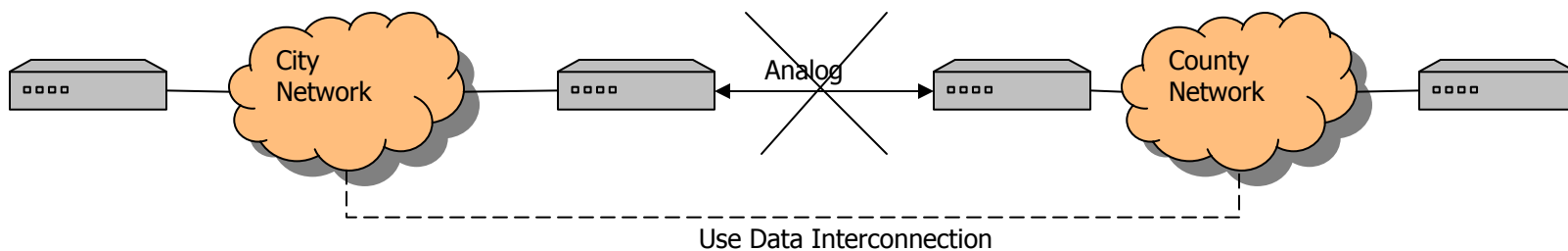
## ■ Audio Processing

- All audio is converted to data packets using one of two processes
  - Waveform coders reproduce the waveform
  - Vocoders reproduce the “sound” of the voice not the waveform
  - The term “vocoder” can be used interchangeably and sometimes means different things depending on the source
- Vocoders are optimized for voice not tones or other signals
  - Cellular phones use vocoders and in many cases background music, etc. is not heard very well and can interfere with the quality of the voice
- Channel banks use waveform coders that more or less accurately reproduce the input waveform

# Technical Details

## ■ Common Waveform and Voice Coders

- G.711 – Basically standard 64 kbps PCM
- G.726 – Basically standard ADPCM 40-16 kbps
- G.723 – CELP Vocoder, 16 kbps
- G.729 – CELP Vocoder, 8 kbps
- Others as technology progresses
- Converting from one to another is called “transcoding”
- Generally, multiple analog to digital conversions are not recommended with true vocoders. Even with PCM there can be some conversion artifacts.



# Initial Considerations

- What type of signals are you carrying over your radio network?
  - Paging
  - Telemetry
  - Other signaling
  - MDC1200 or other status messaging system
  - Not all types of signaling are supported
- Are you using receiver voting?
  - Status tone may not be carried properly.
  - The noise and distortion voting algorithms may not work properly with “vocoded” audio.
- Are you using simulcast?
  - Special channel banks must be used.
  - Proprietary vendor solutions
- Are you recording audio?
  - May require different recording audio source.
  - “Off the Air” recording may be the easiest.



# Initial Considerations

- Shared or dedicated network
- Shared network should support
  - Multicast
  - Bandwidth – Depends on vocoding assume 50k per voice channel worst case
  - Fixed IP addresses
  - Dedicated bandwidth or QoS
  - Virtual LAN's do not guarantee bandwidth
  - Delay must be controlled
  - Router/Firewall programming control
  - Security and virus protection

# Initial Considerations

- Dedicated network should be designed for
  - Multicast supported
  - Bandwidth – Depends on vocoding assume 50k per voice channel worst case
  - Fixed IP addresses
  - Dedicated bandwidth or QoS
  - Virtual LAN's do not guarantee bandwidth
  - Delay must be controlled
  - Router/Firewall programming control
  - Security and virus protection
- How is maintenance going to be handled?
  - Traditionally radio shop handled everything
  - With RoIP multiple departments may be involved

# Initial Considerations

- Computer equipment
  - Operating system compatibility
    - XP
    - Vista
    - Mixed operating systems
  - Compatibility with other software
    - Can the computer be used for anything else?
    - How much horsepower does the application take?
    - Firewalls, anti-virus software, etc.

# Implementing RoIP

## ■ First steps

- Carefully inventory the radio system interfaces and signals to be carried using the factors discussed previously
- Discuss your system interfaces with RoIP vendor or vendors to make sure they are on board with what is required
- Do not expect the vendors to understand all of your requirements. Remember most of them are computer people not radio people.



# Implementing RoIP

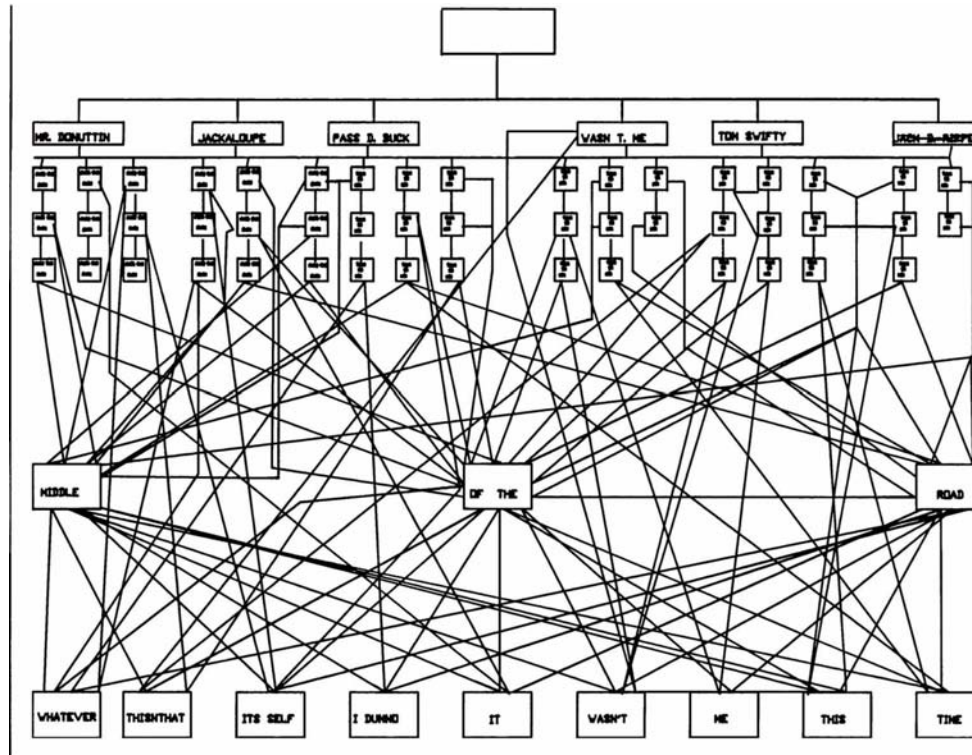
## ■ First Steps

- Discuss the operational portion of the vendor's equipment with the people using the equipment. See if you can obtain demo software.
- Once a vendor has been selected, determine their network requirements and meet with your IT staff to start working out the network issues.
- Do not order equipment until the network requirements have been agreed to by the IT department.



# Implementing RoIP

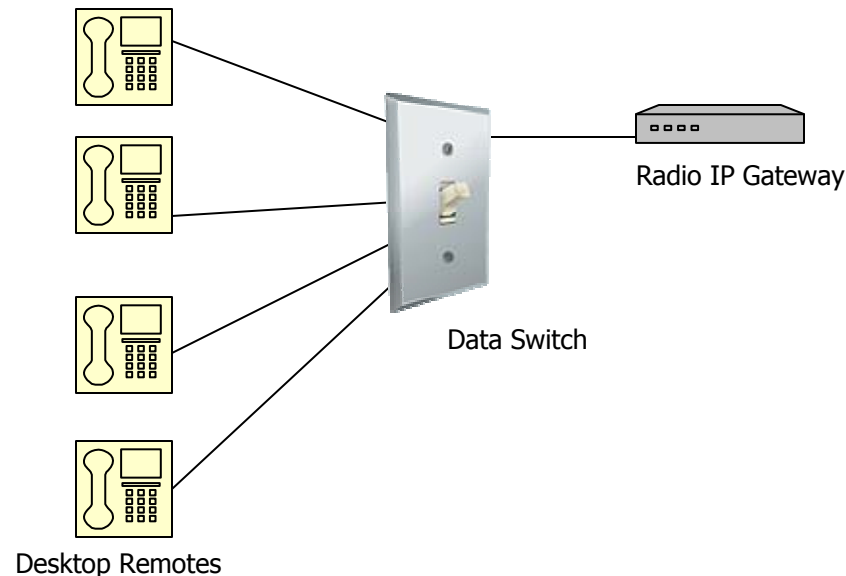
- Document your network!



# Implementing RoIP

## ■ First steps

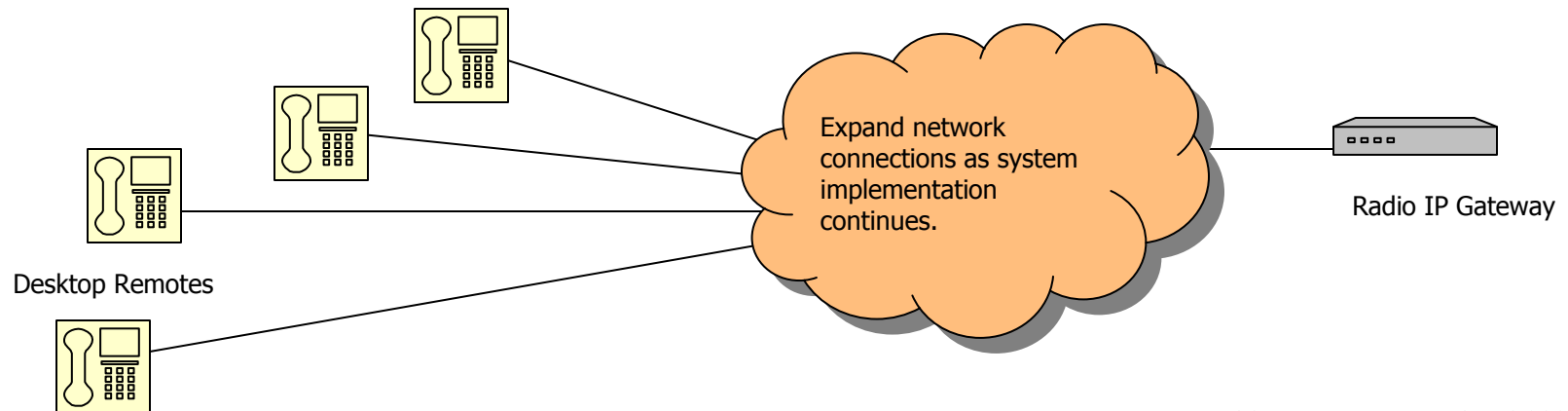
- After equipment arrives, take the time to stage the equipment in the shop and set up programming of each piece of equipment
- Make sure the system operates in the shop before taking it to the sites



# Implementing RoIP

## ■ First Steps

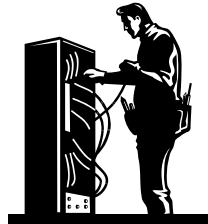
- Verify with IT staff that network programming has been accomplished.
- Start by installing one or two pieces of the equipment first and making sure it is working. Start with the least amount of external network connected.
- Then keep adding equipment until your network is complete.





# RoIP Maintenance

- System maintenance can be more complex
  - Requires a mix of radio and data technologies and most likely two different service entities,  
Radio Shop



and IT



- Troubleshooting will require data networking skills
- Network test equipment may be required
- IT maintenance personnel may work to different standards than radio maintenance personnel
- If system crosses network boundaries, multiple IT departments may become involved



# RoIP – The Future is Now

## ■ Good news

- Can be a very cost effective solution in some situations
- If limitations are not a problem, costs can be reduced
- This technology will eventually become the dominate method for radio system interconnection because most communications are moving to an IP type network
- Improvements in the interfaces are being made all the time
- Some issues are resolved if implemented on a dedicated data network but that raises costs

# Questions?

Thank you!

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