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 ≠ VoIP but there are similarities**
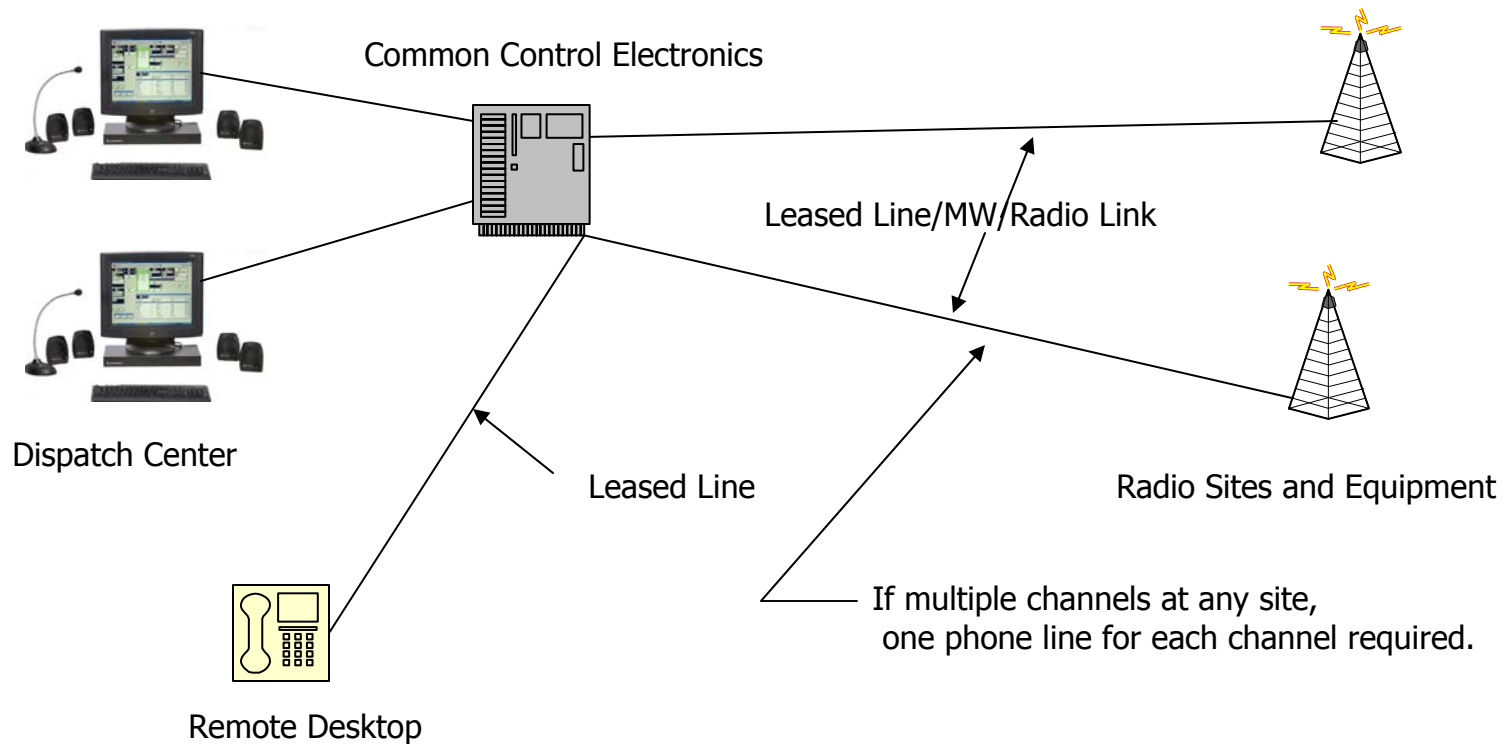- **More alphabet soup –**
  - TCP/IP
  - UDP/IP

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

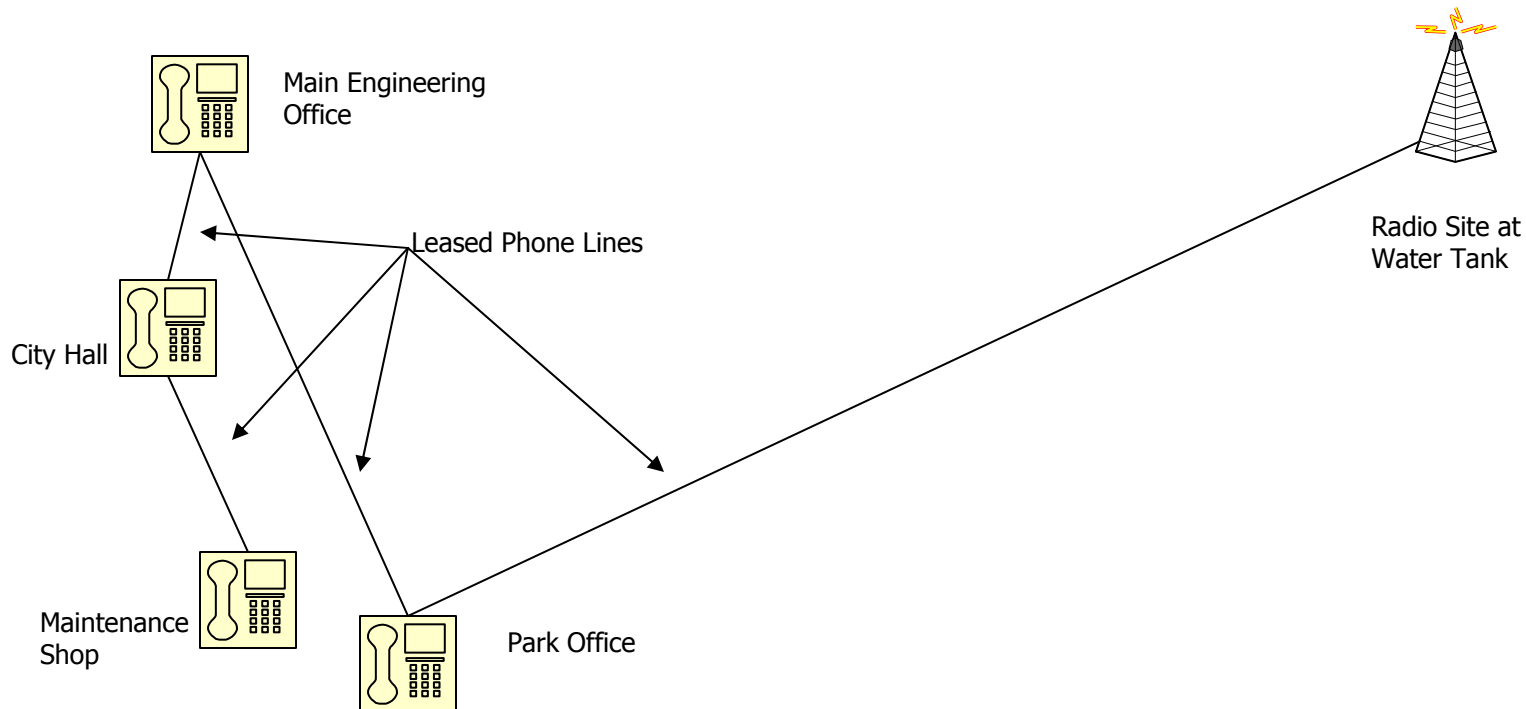ADCOMM Engineering Co. ©2008
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Why RoIP?

- Typical radio network today

Common Control Electronics

Leased Line/MW/Radio Link

Dispatch Center

Leased Line

Radio Sites and Equipment

If multiple channels at any site,
one phone line for each channel required.

Remote Desktop

Why RoIP?

■ Another example

Public Works Radio System

Main Engineering Office

Leased Phone Lines

Radio Site at Water Tank

City Hall

Maintenance Shop

Park Office
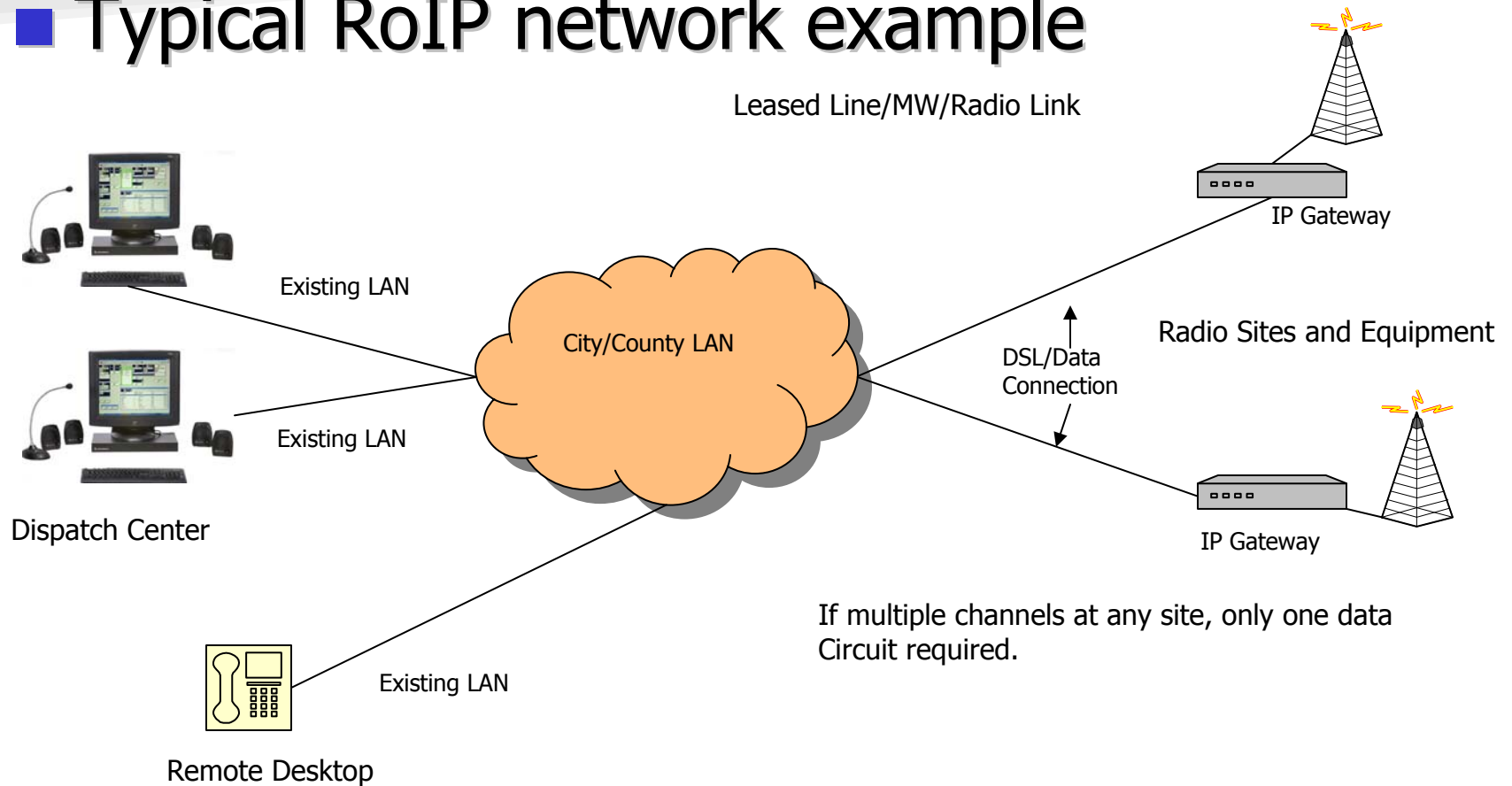
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Why RoIP?

- 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

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Why RoIP?

- ## Typical RoIP network example

Leased Line/MW/Radio Link

IP Gateway

Existing LAN

City/County LAN

Radio Sites and Equipment

DSL/Data
Connection

Existing LAN

Dispatch Center

IP Gateway

If multiple channels at any site, only one data
Circuit required.

Existing LAN

Remote Desktop

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Why RoIP?

■ **Another RoIP example**

Public Works Radio System

Radio Site at Water Tank

DSL/Data Connection

IP Gateway

Main Engineering Office

Existing LAN

Desktop Remote Consoles

Existing LAN Interconnection

City Hall

Existing LAN

City LAN

County LAN

Maintenance Shop

Existing LAN

Desktop Remote Consoles

Existing LAN

Park Office

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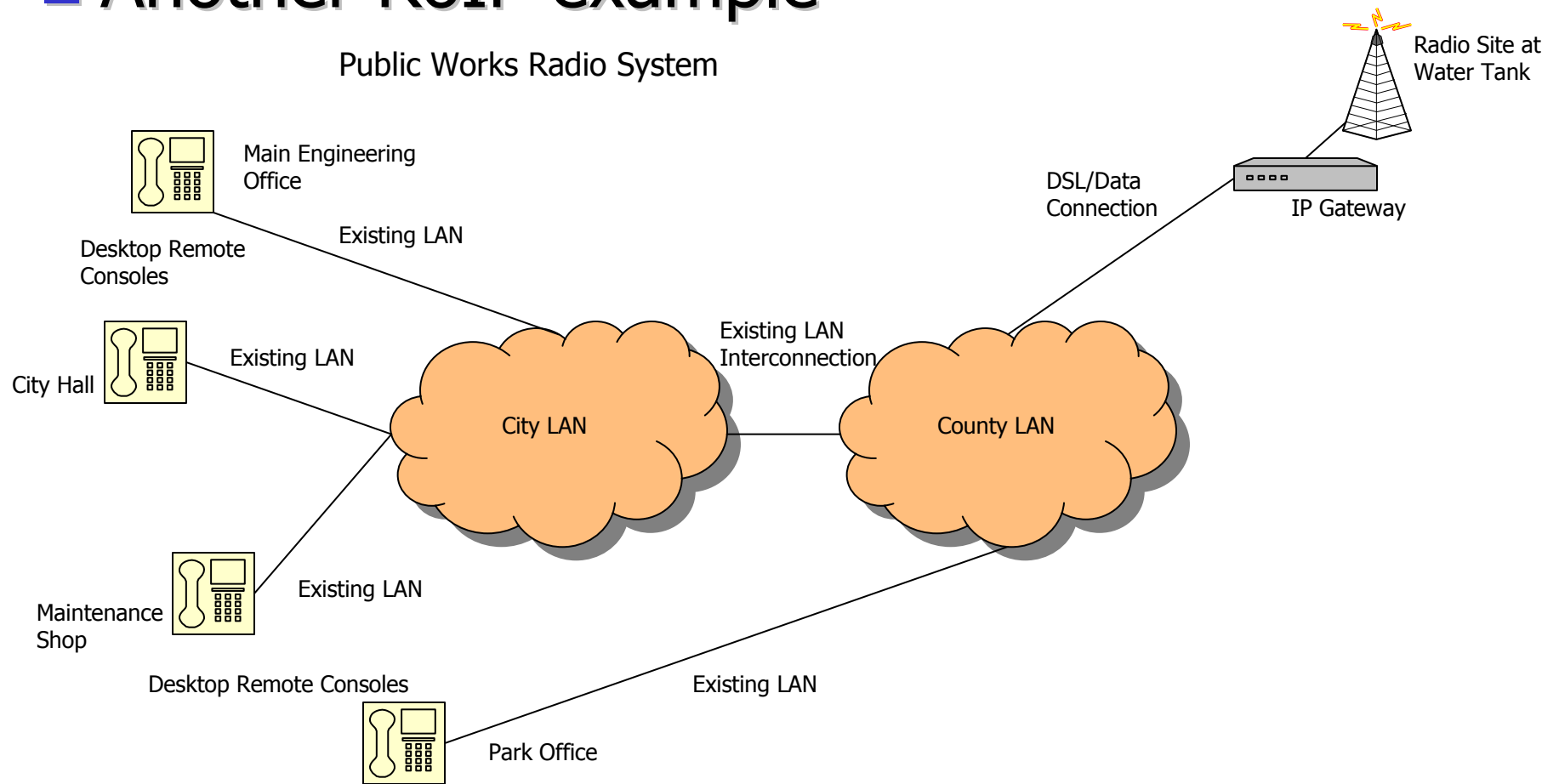
Why RoIP?

- ## Another RoIP example - Backup

Backup Radio System

Radio Site at Water Tank

Dispatch Center

Existing LAN

DSL/Data Connection

IP Gateway

Existing LAN Interconnection

City LAN

County LAN

Existing LAN

Existing LAN

City EOC

County EOC

Wireless Connection

Mobile Command Post
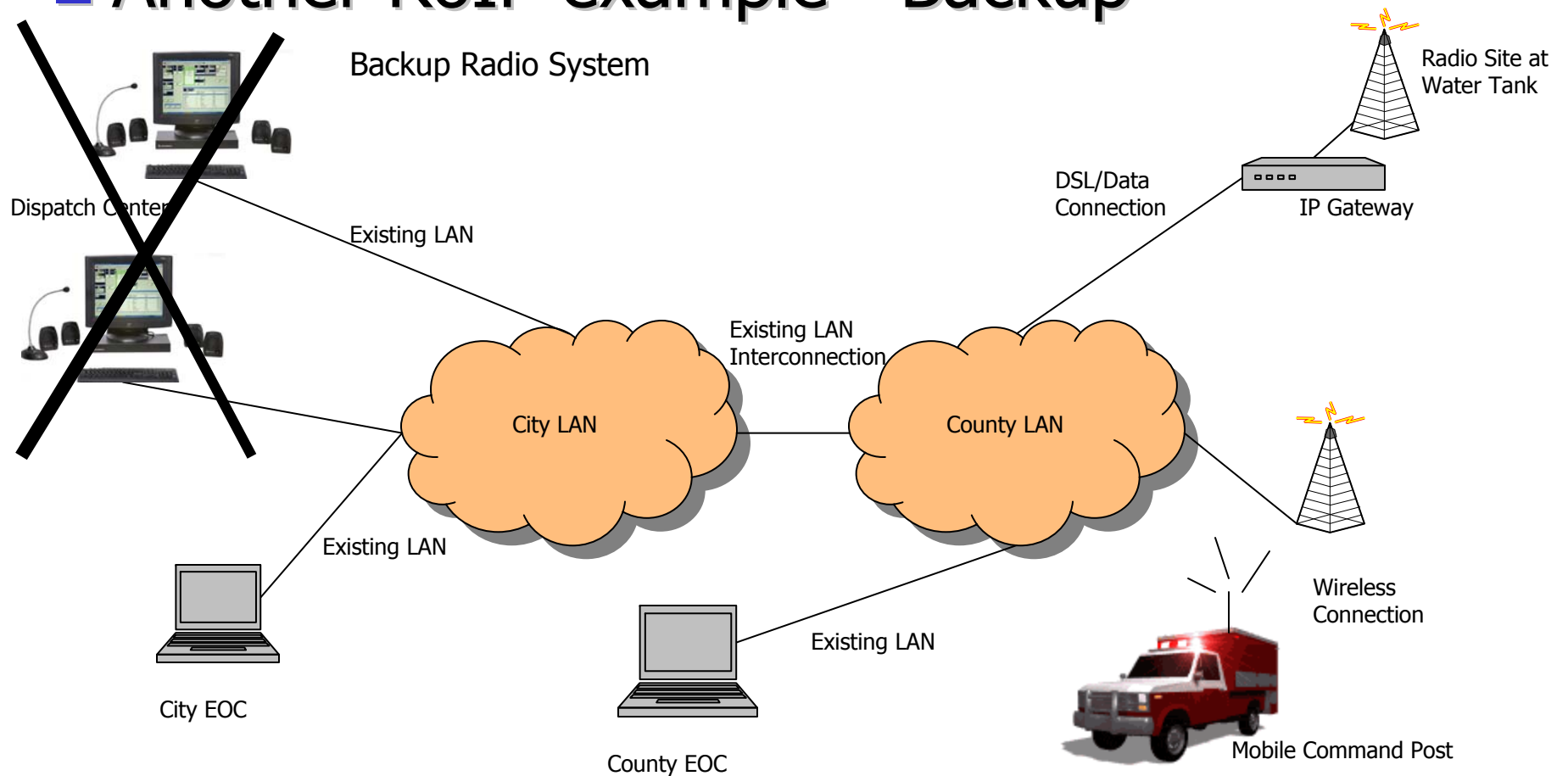
The Promise of RoIP

- 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.
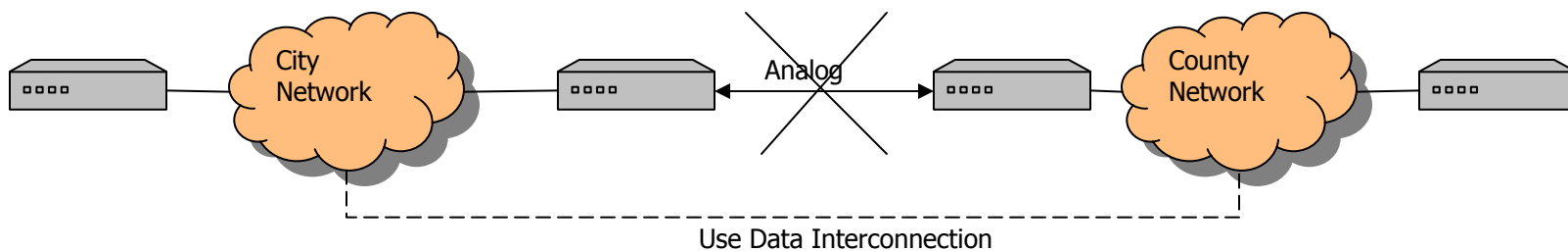- **RoIP is not standardized – Be careful**

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

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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.

City Network

Analog

County Network

Use Data Interconnection

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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.

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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

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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.

Our RoIP product will solve all your communications problems. Just trust me.

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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.

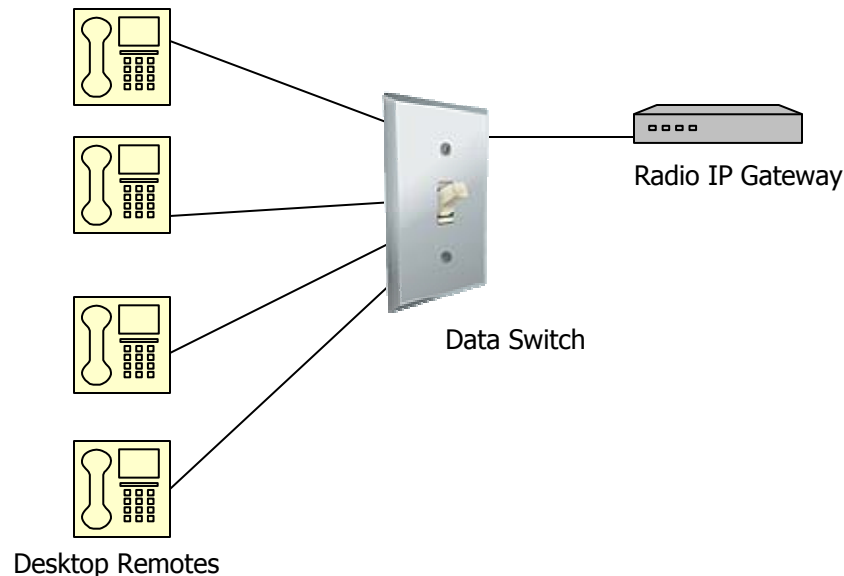ADCOMM Engineering Co. ©2008
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Implementing RoIP

■ Document your network!
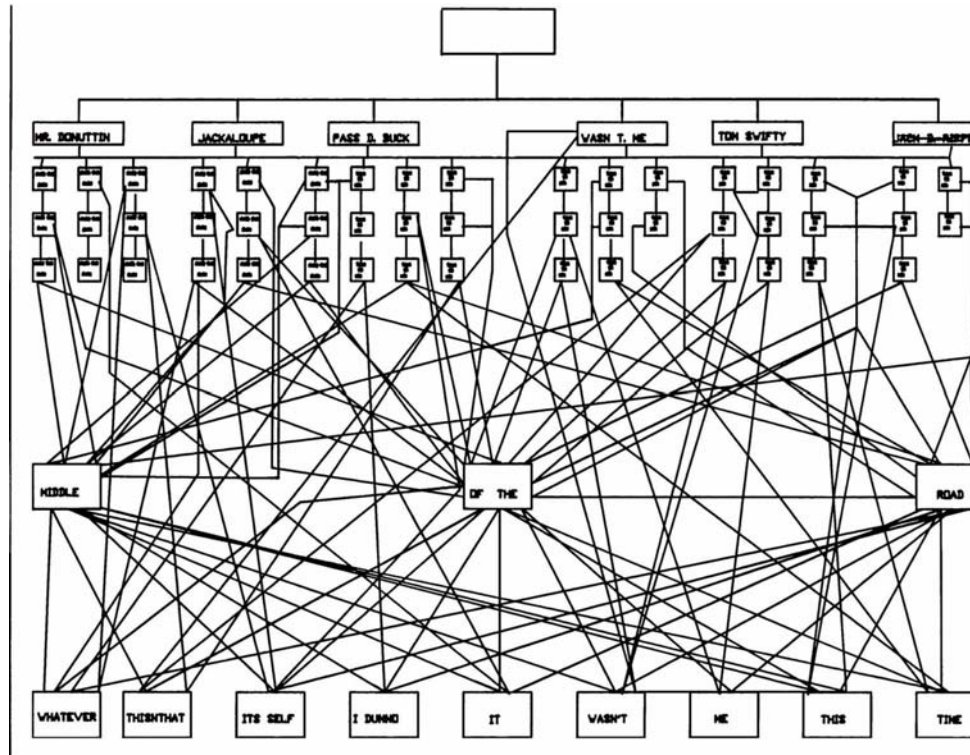
Implementing RoIP

- ## 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

Radio IP Gateway

Data Switch

Desktop Remotes

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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.
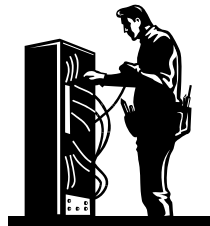 - Then keep adding equipment until your network is complete.

Expand network connections as system implementation continues.

Desktop Remotes

Radio IP Gateway

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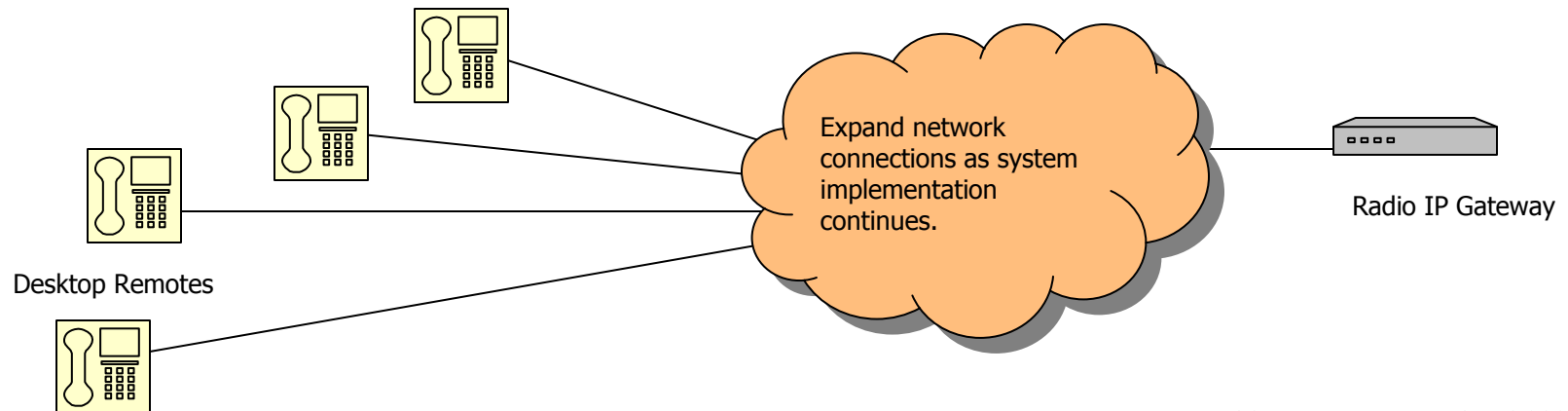
RoIP Maintenance

- **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

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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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