

Anatomy of a Communications Outage

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Cupertino ARES/RACES



CARES mission

The mission of Cupertino ARES is to maintain and train Amateur Radio volunteers capable of providing professional emergency communications, increasing the City's emergency response effectiveness, and speeding the recovery effort.



What telecom do we have today?

What could cause Communications Outages?

What has caused Communications Outages?

What mitigations and contingencies are in place?



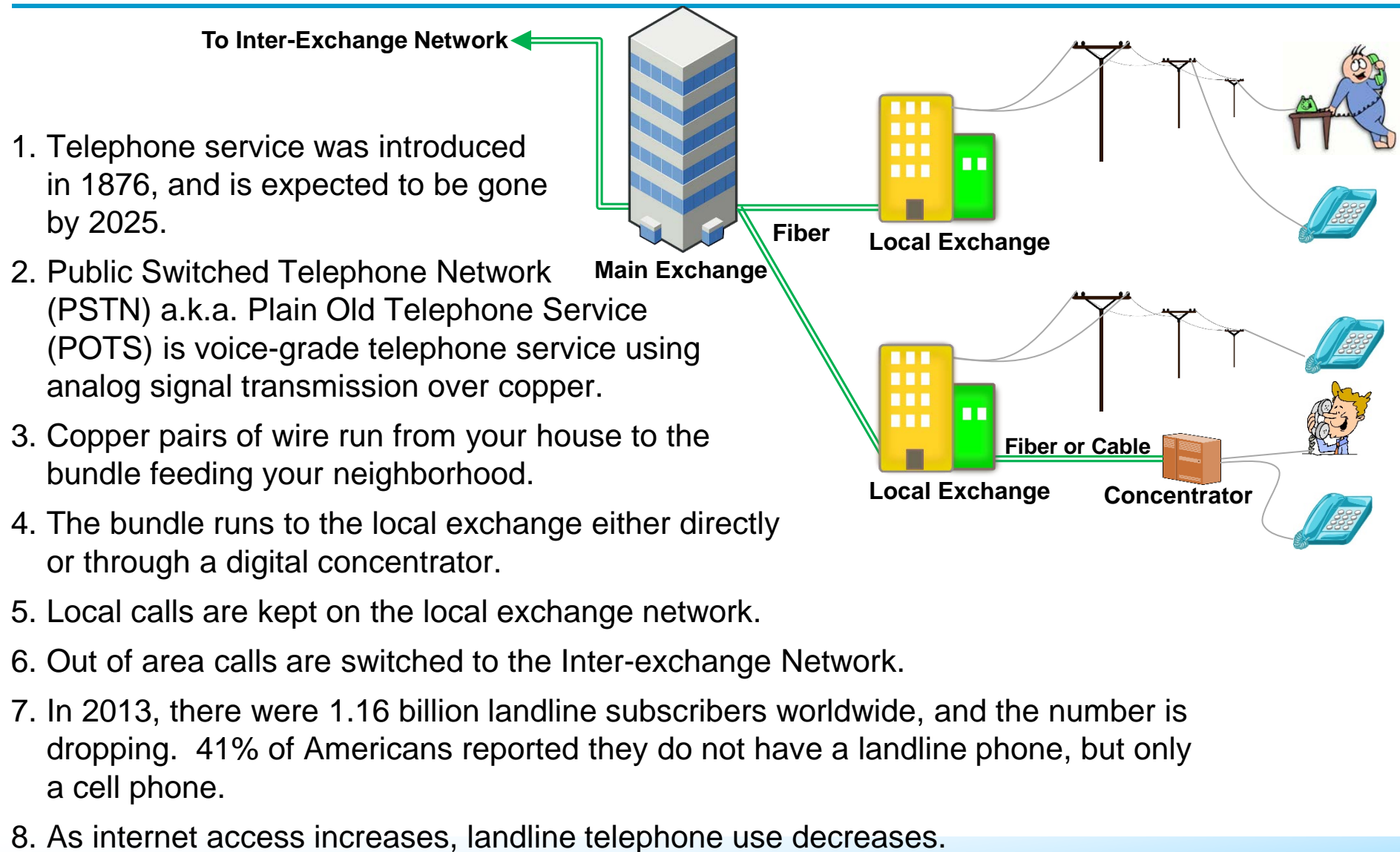
The Big Three

What telecom do we have today?

1. Landline telephone network
2. Cellular phone network
3. Digital broadband network (with VoIP)

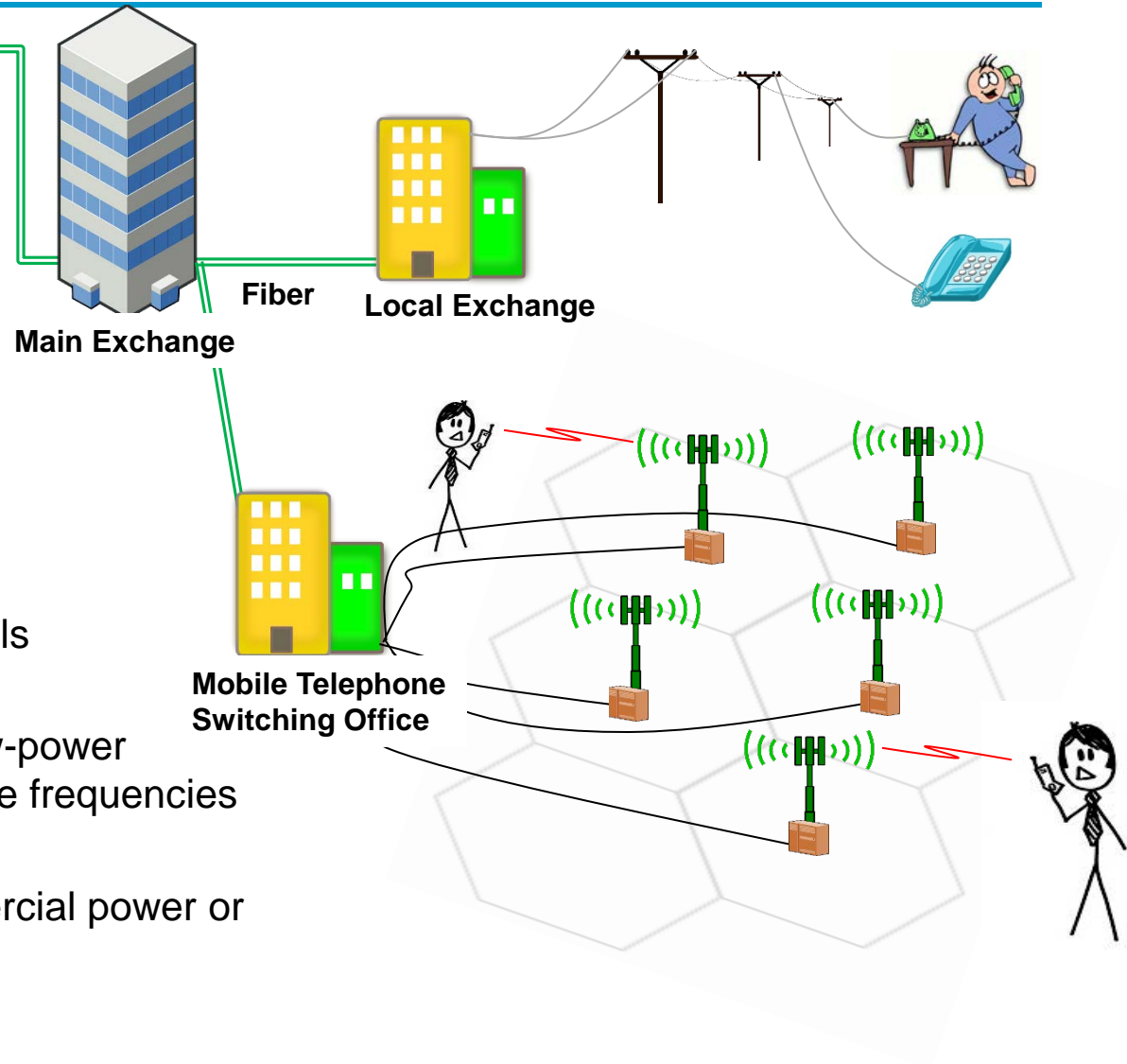


Landline Telephone Network



Cellular Telephone Network

1. Cell service was introduced in the U.S. in 1983.
2. A cell phone service provider gets 832 frequencies:
 - 395 for full duplex voice channels
 - 42 for control.
3. Each cell is typically sized at about 10 square miles (26 square kilometers).
4. For 2G (TDMA), there are 168 channels per cell.
5. Cell phones and base stations use low-power transmitters, thereby allowing the same frequencies can be reused in nonadjacent cells.
6. Most cell sites are powered by commercial power or generators at remote locations.

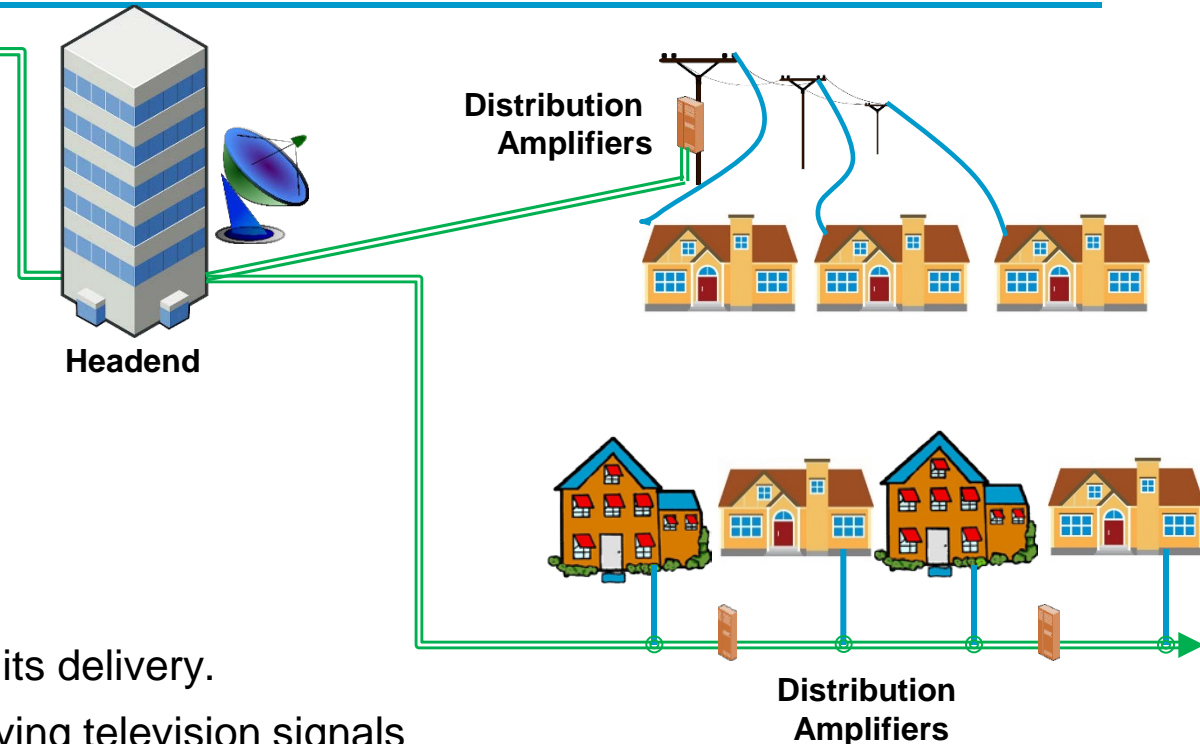


Cable High-Speed Data Network

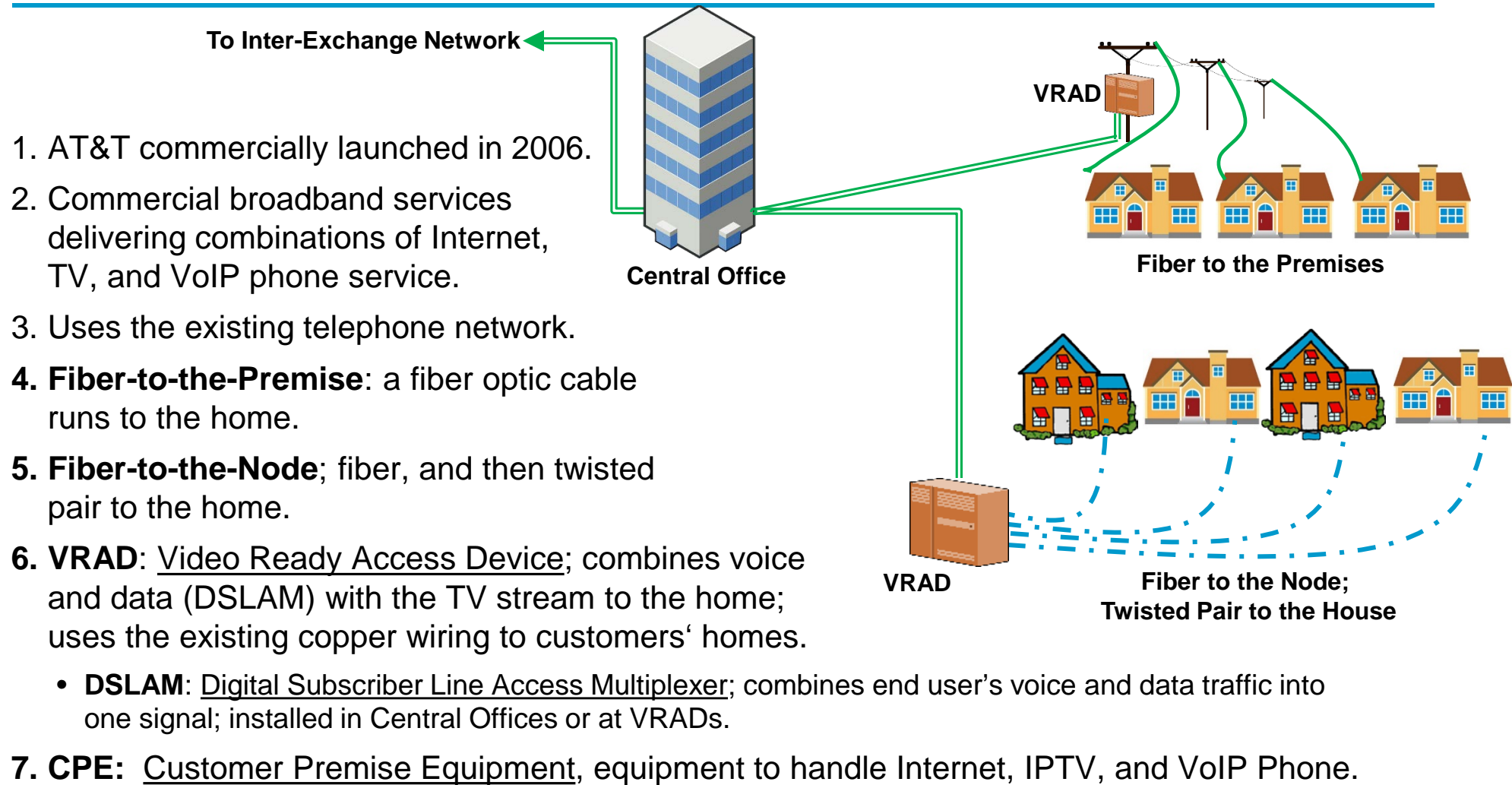
High level view

1. Cable TV was introduced in 1963.
2. Comcast broadband was launched in 1996.
3. Broadband services delivering combinations of Internet, TV and VoIP phone service.
4. One of the most common forms of residential Internet access in the U.S.
5. Uses the existing cable TV system for its delivery.
6. **Headend:** the master facility for receiving television signals for processing and distribution over a cable television system.
7. **Distribution Amplifiers:** ensures a sufficient signal level further down the distribution path.
8. **Network Termination Point:** outside the customer's home, connects to the cable network.
9. **Coax Splitter:** splits signal for TV, Internet, and Phone.

Comcast Regional Area Network,
Inter-exchange Network



DSL High-Speed Data Network



1. AT&T commercially launched in 2006.
2. Commercial broadband services delivering combinations of Internet, TV, and VoIP phone service.
3. Uses the existing telephone network.
4. **Fiber-to-the-Premise:** a fiber optic cable runs to the home.
5. **Fiber-to-the-Node;** fiber, and then twisted pair to the home.
6. **VRAD:** Video Ready Access Device; combines voice and data (DSLAM) with the TV stream to the home; uses the existing copper wiring to customers' homes.
 - **DSLAM:** Digital Subscriber Line Access Multiplexer; combines end user's voice and data traffic into one signal; installed in Central Offices or at VRADs.
7. **CPE:** Customer Premise Equipment, equipment to handle Internet, IPTV, and VoIP Phone.

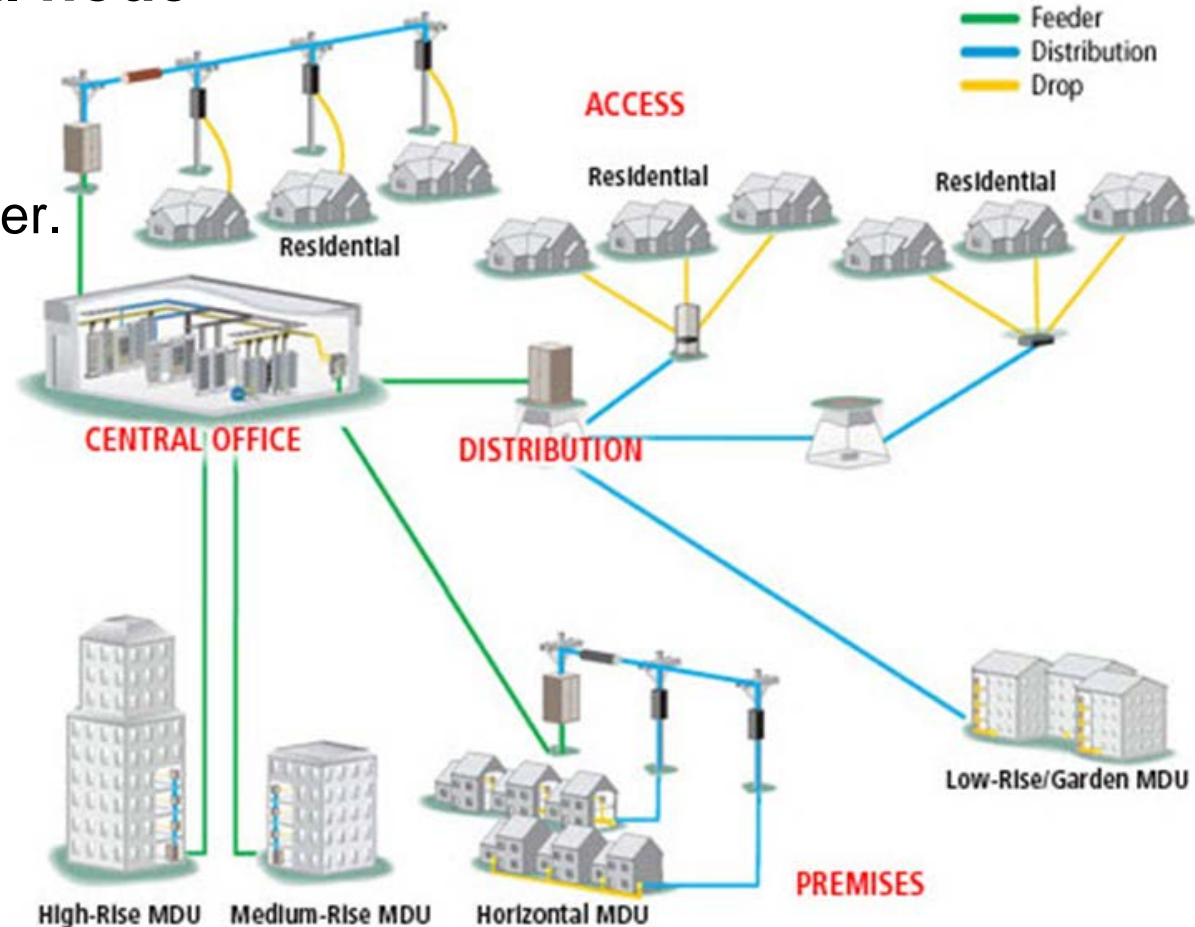


What do they all have in common?

1. All connect to a central node

- Everything connects with the physical world of wire, cable, or fiber sooner or later.

1. Wired Telephone
2. Cellular phone
3. AT&T, Comcast, Sprint, Verizon, other carriers

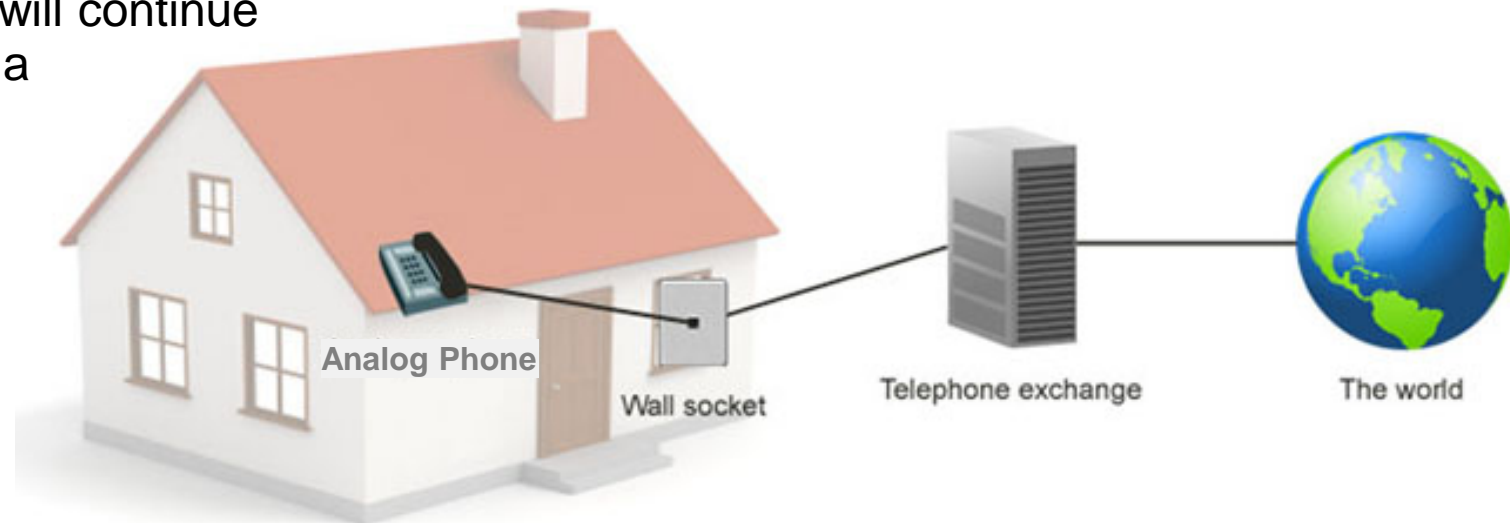


What do they all have in common?

2. All require power to operate

Landline Telephone Network

1. The Phone company maintains an extensive battery system with backup generators at Local Exchange offices.
2. Operates at 6 to 12 volts DC, ~30ma.
3. 90VAC for the ring signal, as provided by the Local Exchange.
4. Wired phones will continue to work during a power failure.

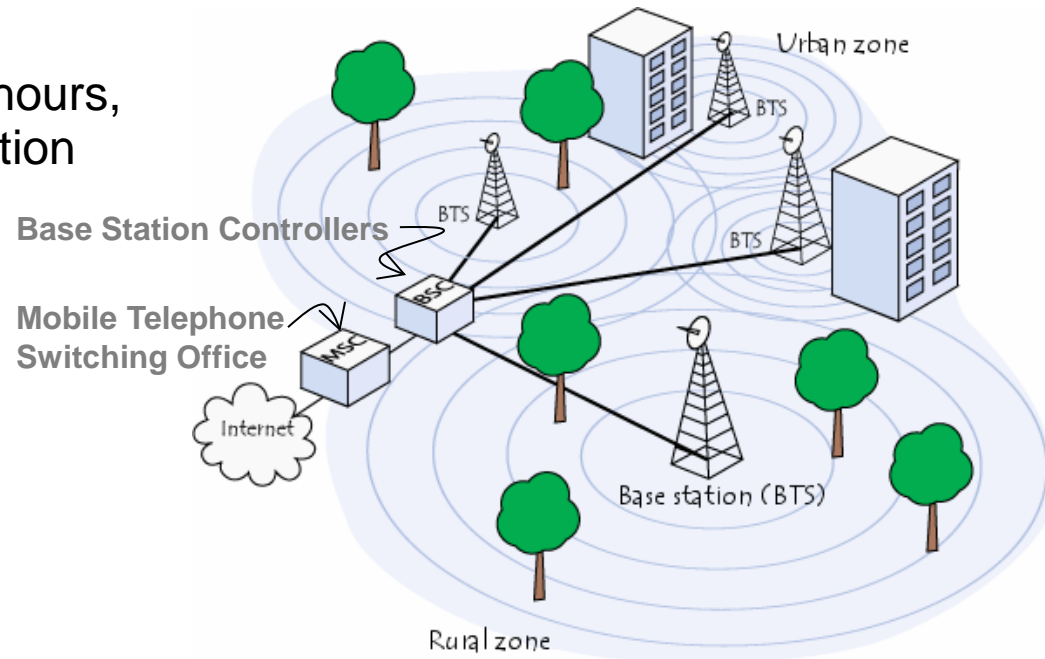


What do they all have in common?

2. All require power to operate

Cellular Telephone Network

1. Towers, controllers fed from commercial power
2. Backup batteries are integrated into most standard power systems the most commonly used power alternatives at cell sites.
3. These batteries can last from 2 to 8 hours, depending on their backup configuration design.
4. Generators are also used to avoid service interruption.

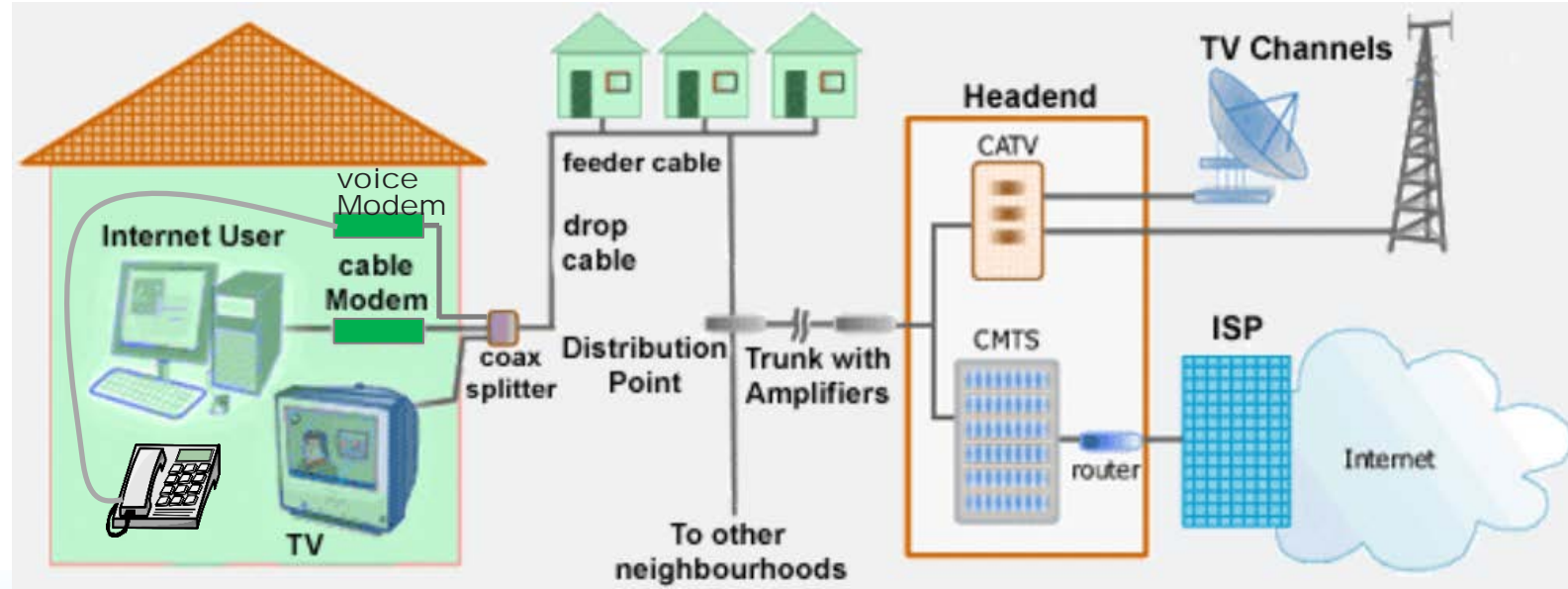


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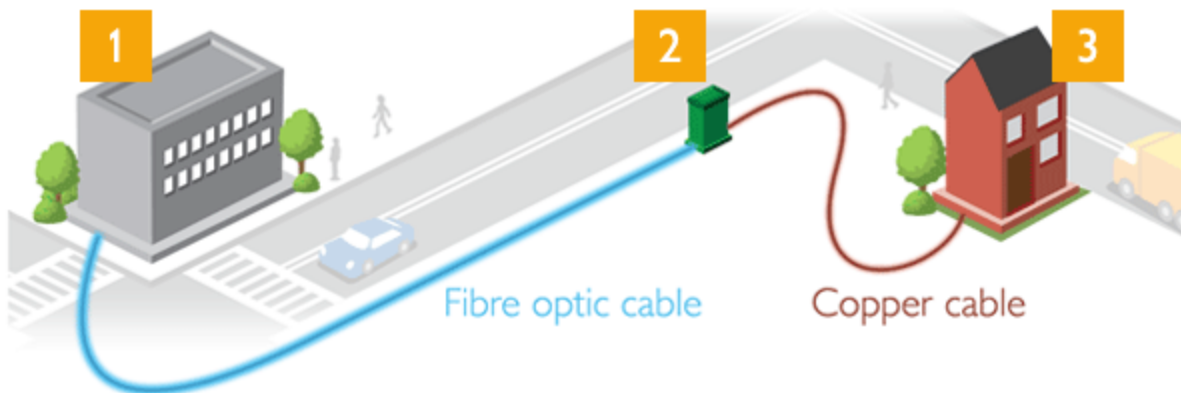
Comcast Digital Network

1. Central Office / Headend: backup generators, batteries.
2. The *voice phone modem* requires a backup battery to ensure telephone service remains operational during a power outage



What do they all have in common?

2. All require power to operate *AT&T Digital Network*



1. Central Office: backup generators, batteries.
2. VRAD Neighborhood boxes; includes NiMH backup battery; operates for about 2 to 4 days on battery during a power failure.
3. WiFi Resident Gateway; with voice services; package includes a backup battery (Belkin 12V, 7.2Ahr SLA shown here).



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What could cause communications outages?

- **Loss of Connectivity**

- Cable breaks – accidental, intentional, natural

- **Loss of Power**

- Power failure, and no backup system available
- Power failure, and backup systems fail
 - Generators fail
 - Batteries – infrastructure equipment or personal – are exhausted
- Intentional disruption

- **System Overload**

- Some *out-of-the-ordinary* event causes **a lot** of people to use the phone.



What has caused communications outages?

Loss of Connectivity

Accidental

- **2013, Washington.** Underwater fiber-optic cable became wrapped around a big rock and broke; some residents of Washington state's San Juan Islands were without Internet and telephone service for 10 days.
- **March 2012, Morgan Hill.** Most Verizon phone and Internet connections were down for the day because a major fiber-optic cable was accidentally cut.
- **March 2015, Arizona.** Several thousand people lost Internet and phone service for 12 hours when an electric company crew accidentally cut a fiber-optic line in northern New Mexico.



What has caused communications outages?

Loss of Connectivity

Intentional – in the news

- **April 2009, San Jose.** underground fiber-optic cables in California were cut at four sites, knocking out landlines, cell phones and Internet service for tens of thousands in Santa Clara, Santa Cruz and San Benito counties. 9-1-1 was unavailable.



What has caused communications outages?

Loss of Connectivity

Intentional – in the news

- **September 3, 2015, CA North Coast.** A vandal severed a critical AT&T fiber cable in Hopland on Thursday, disrupting Internet, landline and cellphone service across a broad swath of the North Coast, including much of Mendocino and Humboldt counties and parts of Sonoma and Lake counties.
- **July 15, 2015, San Joaquin County.** Fiber optic line intentionally cut causes 9-1-1 outages; impacted Verizon Wireless and AT&T customers in the region. Not copper thief, but pure vandalism; 10 hour outage.
- **July 1, 2015, San Jose.** Someone broke into an underground vault and cut three fiber-optic cables belonging to service providers Level 3 and Zayo.
- **June 30, 2015, Sacramento.** Bay Area vandalism disrupts service to Sacramento, Rocklin Wave Broadband customers; three major fiber cables connecting the region were cut; ~15 hour outage
- **February 2015, Arizona.** Tens of thousands of residents were without Internet service after vandals cut through an underground bundle of fiber-optic cables owned by CenturyLink. ATMs went down, stores couldn't process credit cards, and 9-1-1 emergency service was unavailable. ~15 hour outage.



What has caused communications outages?

Loss of Connectivity

Intentional – and then the FBI report-out... even more cable cuts throughout the Bay Area

- July 6, 2014, 9:44 p.m., Berkley. Near 7th St. and Grayson St.
- July 6, 2014, 11:39 p.m., Fremont. Near Niles Canyon Blvd. and Mission Blvd.
- July 7, 2014, 12:24 a.m., Walnut Creek. Near Jones Road and Iron Horse Trail.
- July 7, 2014, 12:51 a.m., Fremont. Near Niles Canyon Blvd. and Alameda Creek.
- July 7, 2014, 2:13 a.m., San Jose. Near Stockton Ave. and University Ave.
- Feb 24, 2015, 11:30 p.m., Fremont. Near Niles Canyon Blvd. and Mission Blvd.
- Feb 24, 2015 11:30 p.m., Fremont. Near Niles Canyon Blvd. and Alameda Creek
- June 8, 2015, 11:00 p.m., Alamo. Near Danville Blvd. and Rudgear Road.
- June 8, 2015, 11:40 p.m., Fremont. Near Overacker Ave. and Mowry Ave.
- June 9, 2015, 1:38 p.m., Walnut Creek. Near Jones Road and Parkside Dr.



What has caused communications outages?

Loss of Connectivity

Observations

- As of 2013...
 - Cell vs Landline Phones: 41% of households did not have a landline phone.
 - 91% of adults own a mobile phone
- Companies have been deploying more than **10 million miles of fiber annually** in the U.S., **increasing the risk** of damage from backhoes, trench-diggers and shovels.
- U.S. Commerce Department's National Institute of Standards and Technology warned in 1995 that the "power of optical fiber technology is **diminishing the number of geographic transmission routes**," concentrating the flow of information and "resulting in an **increase in network vulnerability**."
- The FCC reported that the number of outages on high-capacity fiber-optic lines in the U.S. more than doubled from **221 in 2010 to 487 in 2014**.
- Companies generally do not build alternative routes, or redundancies, unless they believe it is worthwhile financially.

What has caused communications outages?

Loss of Power

Accidental / Natural

- Sept 2005, Hurricane Katrina
- Dec 2012, Hurricane Sandy
- Tornados, Earthquakes, etc.
- Others?



What has caused communications outages?

Loss of Power

Intentional

- April 16, 2013, San Jose, *WSJ*.
Assault on California Power Station Raises Alarm on Potential for Terrorism.
April Sniper Attack Knocked Out Substation, Raises Concern for Country's Power Grid
- Cut telephone cables.
- 20 minutes of shooting at the Power Station.
- Knocked out 17 giant transformers that deliver power to Silicon Valley.
- 27 days to make repairs and bring the substation back on line.

*If it were widely replicated across the country, could take down the U.S. electric grid and black out much of the country; **loss of communications would follow.***



Shots in the Dark

A look at the April 16 attack on PG&E's Metcalf Transmission Substation

1	2	3	4	5	6	7
12:58 a.m., 1:07 a.m. Attackers cut telephone cables	1:31 a.m. Attackers open fire on substation	1:41 a.m. First 911 call from power plant operator	1:45 a.m. Transformers all over the substation start crashing	1:50 a.m. Attack ends and gunmen leave	1:51 a.m. Police arrive but can't enter the locked substation	3:15 a.m. Utility electrician arrives

Sources: PG&E; Santa Clara County Sheriff's Dept.; California Independent System Operator; California Public Utilities Commission; Google (image); The Wall Street Journal



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Coolant leaks out from around the transformers

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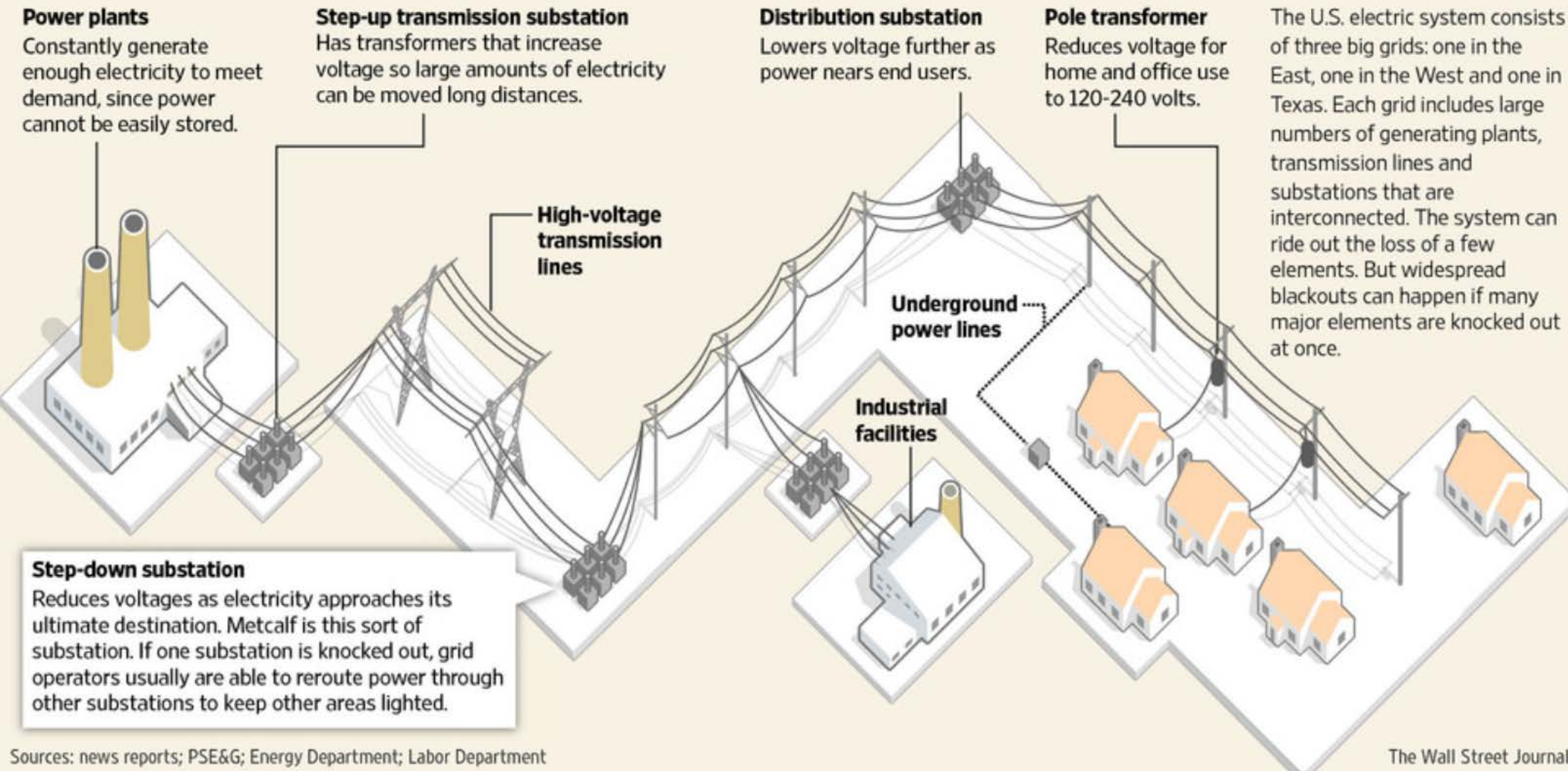
Sources: PG&E; Santa Clara County Sheriff's Dept.; California Independent System Operator; California Public Utilities Commission; Google (image); The Wall Street Journal



What has caused communications outages?

Loss of Power

Grid Lines | How a typical electric system works



What has caused communications outages?

Loss of Power

Summary

- Parts of the U.S. power grid are attacked online or in person every four days, according to an analysis of federal energy records.
- From 2011 to 2014, the U.S. Department of Energy received 362 reports from electric utilities of physical or cyber attacks that interrupted power services.
- The Department of Homeland Security was alerted to 151 energy-related “cyber incidents” in 2013, up from 31 in 2011 and 111 in 2012.



What has caused communications outages?

(Potential) Loss of Power

Intentional

- March 5, 2014, Senoia, GA. **Thieves target AT&T cell phone tower batteries**, and selling cell phone tower batteries for scrap for \$28 each. About 500 total were stolen until the thieves were caught.
- May 21, 2015, King of Prussia, PA. **Technician accused of stealing 4,000 cell phone tower batteries**, thefts across 4 states, sold to a recycler for \$30 each.
- June 9, 2015, Enid, OK. **Thieves steal batteries from cell phone towers**, report referenced 3 different thefts over a 3 month period.

... and other stories

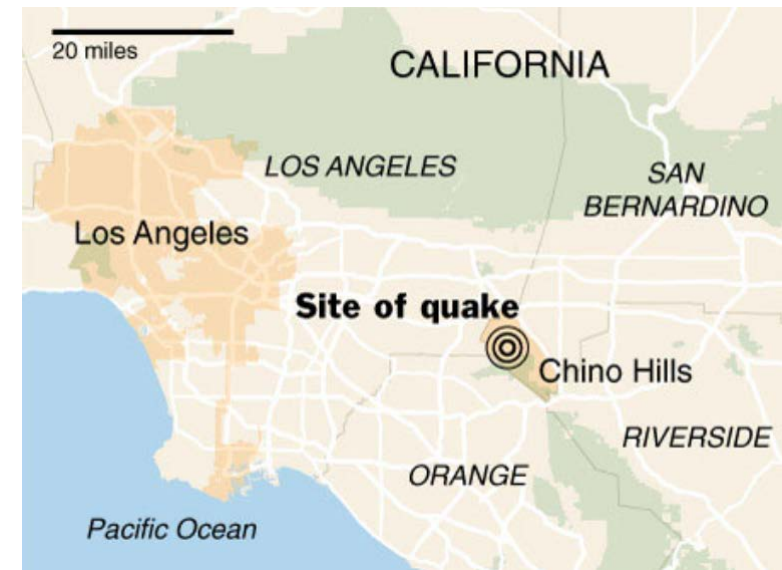


What has caused communications outages?

System Overload

Natural (2 examples)

- July 30, 2008, Los Angeles.
Magnitude 5.4 earthquake, centered near Chino Hills in San Bernardino County. **Cell phone lines were jammed** throughout the region as people frantically made calls immediately after the jolt. CA OES urged Californians to free up the lines for emergency use. No damage reported to the network infrastructure.
- August 23, 2011, Washington DC.
Magnitude 5.8 earthquake struck central Virginia at 1:53 pm EST. **Cell phone networks were jammed** in Manhattan, Washington D.C., and other areas. SMS could get through. Major carriers reported no major problems with their network infrastructure.



Mitigating communications outages

At the Federal Level

Outcome from Katrina

FCC ORDER ON RECONSIDERATION

ATTEMPTED: October 2, 2007... *Overtured in the courts*

Local exchange carriers (LECs), including incumbent LECs (ILECs) and competitive LECs (CLECs), and commercial mobile radio service (CMRS) providers **must have an emergency backup power source** for all assets that are normally powered from local AC commercial power, including those inside central offices, cell sites, remote switches and digital loop carrier system remote terminals.

Outcome from Sandy

September 27, 2013.

The FCC voted to adopt draft rules that would require carriers to publicly disclose the percentage of cell sites within their networks that are working during and immediately after disasters.



Mitigating communications outages

At the local level

City of Cupertino Operational Systems	Primary Service Provider	Backup Service Provider	Emergency Backup
Telephone, Wired	AT&T		MSAT G2 Sat Phone CARES, Part 97, Voice
Telephone, Cellular	Verizon		MSAT G2 Sat Phone CARES, Part 97, Voice
Internet	(1) AT&T (main) (2) Comcast business class (wifi)	Excede Satellite Internet	Infralink ARKnet (2016)
TV, Broadcast, reception	Comcast Xfinity	DirectTV & Dish Network	
TV, Broadcast, transmission	City-owned, cable feed to AT&T and Comcast	None	
Radio, Broadcast, transmission	City-owned, TIS		
Radio, Broadcast, Reception	Commercial radio stations	Personal AM/FM radios	
Radio, City Operations, 2-Way	City-owned, Part 90 Trunk		CARES, Part 97, Voice
Digital Messaging (email)	City-owned		CARES, Part 97, Packet
Wide Area Fiber Network	City-owned; connections to the Sports Center, Senior Center, Quinlan Center, TOC.		ARKnet (2016)



Communications Outage take-aways

Landline Telephone Network

1. With power, will work
2. Without power, will work, but must have a wired (nor cordless) phone

Cellular Network, no power

- | | |
|-------------------------|--------------------|
| 1. Cell phone towers... | 8 hours to ~2 days |
| 2. Smart Phone... | 24 hours |

DSL/Cable, no power

- | | |
|--|--------------|
| 1. VRAD backup batteries... | up to 4 days |
| 2. Home WiFi Gateway batteries... | 4 – 8 hours |
| 3. Home Cable Voice Modem Batteries... | 8 – 24 hours |



Communications Outage take-aways

If...

- we had a multi-day power failure caused by storms, earthquake, or some intentional means, and/or...
- It lead to a home phone communications failure (for whatever reason),

Then how would we do to support the community?

This is the focus for our 21-November Communications Exercise.



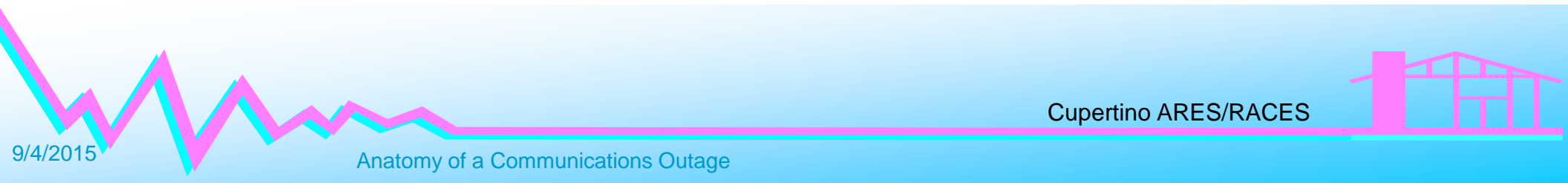
On the horizon

1. *October 1st CARES meeting*
SCC FD Volunteer Communications Package Overview
2. *November 5th CARES meeting*
Drill Prep
3. *November 21st CARES drill*
Full field communications exercise



Thank you

Any Questions?



9/4/2015

Anatomy of a Communications Outage

Cupertino ARES/RACES



Cellular Frequencies

Current / Planned Technologies	Previous Technologies	Band	UHF Frequency (MHz)
3G, 4G, MediaFLO (defunct), DVB-H	UHF TV 52-69 (698-806 MHz)*	700	698–806
SMR iDEN, ESMR CDMA (future), ESMR LTE (future)	UHF TV 70-83 (806-890 MHz)	800	806–824 and 851–869
GSM, IS-95 (CDMA), 3G	AMPS, IS-136 (D-AMPS)	850	824–849 and 869–894
Unknown		1400	1,392–1,395 and 1,432–1,435
GSM, IS-95 (CDMA), 3G, 4G	IS-136 (D-AMPS)	PCS	1,850–1,910 and 1,930–1,990
3G, 4G		AWS	1,710–1,755 and 2,110–2,155
4G		BRS/EBS	2,496–2,690

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References

<http://electronics.howstuffworks.com/telephone.htm>

https://en.wikibooks.org/wiki/Communication_Systems/Telephone_System

<http://smallbusiness.chron.com/office-phone-systems-work-31104.html>

<http://computer.howstuffworks.com/ip-telephony.htm>

<http://electronics.howstuffworks.com/cell-phone.htm>

<http://computer.howstuffworks.com/dsl.htm>

<http://adslm.dohrenburg.net/uverse/>

https://en.wikipedia.org/wiki/Video-ready_access_device

https://en.wikipedia.org/wiki/AT%26T_U-verse

<https://www.google.com/search?q=picture+of+telephone+local+exchange&ie=&oe=>

<https://www.google.com/search?q=picture+of+pots+local+telephone&ie=&oe=>

<https://www.google.com/search?q=picture+of+cellular+telephone+system&ie=&oe=>

<http://www.cpuc.ca.gov/NR/rdonlyres/FFE91CE3-D2E2-4CCE-97A3-239493CDC5F5/0/MicrosoftPowerPointPRSWorkshopATTV11.pdf>

