Anatomy of a Communications Outage

23 January 2016
Jim Oberhofer KN6PE

Thursday morning, 8:00am
Bay Area power outage

Almost all of the Bay Area woke up (late) with no power.

As people scrambled to find their smartphones or battery-powered AM Radios, they learned that as massive power failure occurred sometime early Thursday morning, about 2:15am, that took out most of northern California's power system. PG&E and CAISO issued press releases saying that finding and fixing the cause of the outage is in progress.

PG&E ®

MY HOME | MY BUSINESS | BUSINESS TO BUSINESS

My Bill & Account | Service Requests | Outages | Find

⋓ Electric Outage Center

Electric Reliability

Gas Outage Center

Electric Outage Cente

Report an outage: Begin entering a

23 January 2016

Thursday afternoon, 1:00pm
Bay Area power outage

10 hours into the blackout.

PG&E reported that some unidentified fault was hampering them from bringing up the power grid per their usual procedures.

- The ***good news*** is that they isolated the source of the problem to the Cortina Substation, about 73 miles north of Sacramento.

- The ***bad news*** is that the cause is still unknown.

Friday morning, 8:00am
Bay Area power outage

30 hours into the blackout.

County OES holds a press conference:

- Essential services remain in operation throughout most of the bay area. Some backup power systems failed.

- Telephone networks are operational, but an increased demand left many circuits overloaded.

- Water systems in a few cities lost pressure forcing boil-water advisories to be put into effect.

- Cellular service is spotty due to call volume.

- Major cellular providers are now on backup power.

- Most Commercial TV, radio stations are still on the air.

Friday afternoon, 3:00pm
Bay Area power outage

38 hours into the blackout.

A joint press conference was held with County OES, PG&E, and several telephone/internet carriers. The news is not good.

- Still no exact cause for the problem, but they now suspect a software bug or worse… a worm or virus.

- Attempts to bring up the grid have failed; PG&E thinks this could go on for another 24 hours.

- AT&T and other carriers state that their networks continue to be overloaded, long delays getting a dial tone, and some backup power systems have started to fail.

- Wireline services are working, but most VRAD backup batteries will run down tonight.

Friday afternoon, 4:00pm

Bay Area power outage

39 hours into the blackout.

The Cupertino City Manager requested ARES and CERT teams to activate Saturday _if they wake up to no telephone service at home_. The request is to do the following:

- Set up communications outreach locations throughout the City to pass on information and relay resident requests for help.
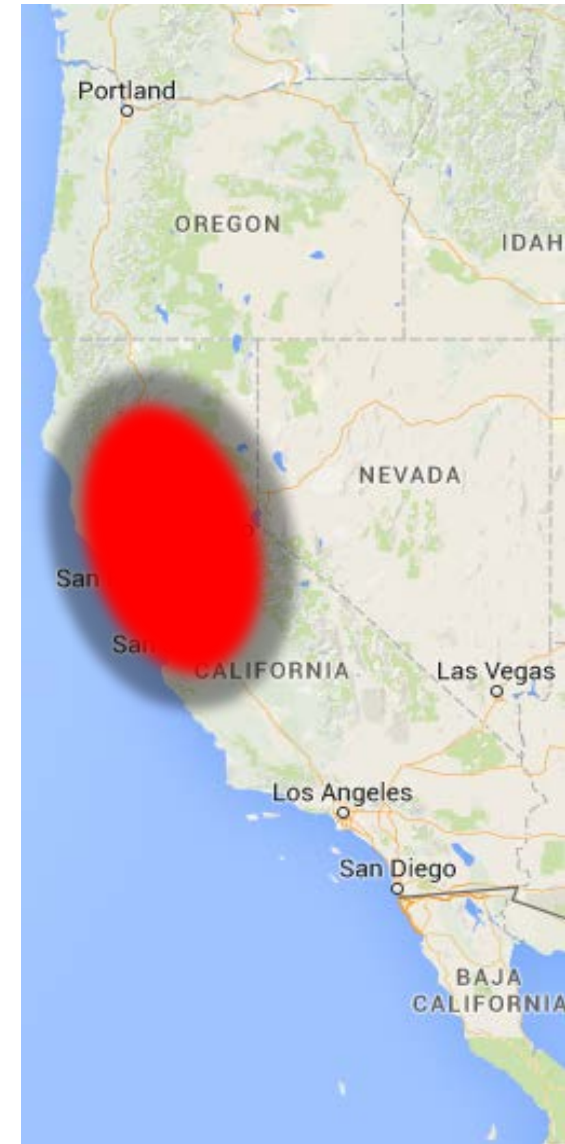
- Support the EOC.

Saturday early morning, 1:30am
Bay Area power outage

Almost 48 hours into the blackout.

- Wireline and cell phone communications fail throughout all of Santa Clara County.

- No dial tones were heard on picking up the telephone handset.

- Placing 911 calls is no longer possible.

Is this scenario likely?

Internet infrastructure is vulnerable to attacks that can cause prolonged outages

By Felicia Fonseca and David A. Lieb | Associated Press

2 COMMENTS

FLAGSTAFF, Ariz. -- When vandals sliced a fiber-optic cable in the Arizona desert last month, they did more than time-warp thousands of people back to an era before computers, credit cards or even phones. They exposed a glaring vulnerability in the nation's Internet infrastructure: no backup systems in many places.

BUSINESS

Internet infrastructure is vulnerable to attacks that can cause prolonged outages

By Felicia Fonseca and David A. Lieb | Associated Press

POSTED: 03/27/2015 12:24:22 PM PDT | UPDATED: 10 MONTHS AGO

2 COMMENTS

…vandals sliced a fiber-optic cables…

…accidental fiber-optic line cuts…

…underwater fiber-optic cable breaks…

…warnings about such vulnerabilities made two decades ago

Could this happen here?

Looking for the background
- National Infrastructure Protection Plan
- Critical Infrastructure Sectors

1. Chemical
2. Commercial Facilities
3. Communication
4. Critical Manufacturing
5. Dam
6. Defense Industrial Base
7. Emergency Services
8. Energy

9. Finance Services
10. Food and Agriculture
11. Government Facilities
12. Healthcare and Pub Health
13. Information Technology
14. Nuclear Reactor, Mat'ls, Waste
15. Transportation Systems
16. Water and Wastewater

Could this happen here?

Looking for the background
- National Infrastructure Protection Plan
- *Communications Sector-Specific Plan*

Developing a view for a local risk assessment

Potentially impacted systems
- Telephony
- Internet
- Radio
- Messaging
- Video

What could fail?

Impacting Events
- Loss of Power
- Loss of Connectivity
- System Overload

What could cause a failure?

Risks (& recommendations)

How likely is a failure to occur?

Landline Telephone Network

1. Telephone service was introduced in 1876.

2. Public Switched Telephone Network (or Plain Ol' Telephone System -- POTS) is voice-grade telephone over copper.

3. Copper pairs of wire run from your house to the local exchange either directly or through a digital concentrator.

4. Local calls are kept local; Out of area calls are switched to the Inter-exchange Network.

5. In 2013, there were 1.16 billion landline subscribers worldwide.

To Inter-Exchange Network

Main Exchange

Fiber

Local Exchange

Local Exchange

Fiber or Cable

Concentrator
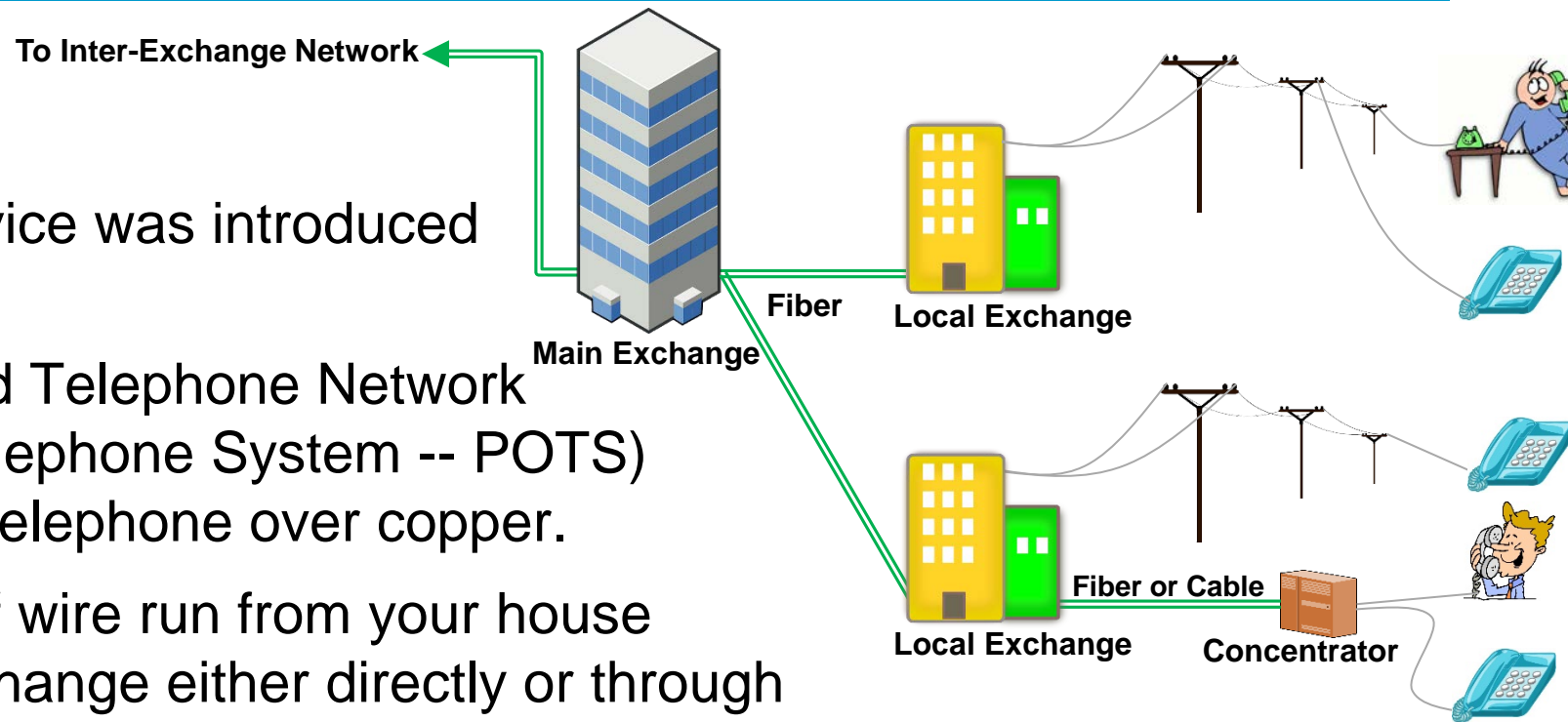
Cellular Telephone Network

1. Cell service was introduced in the U.S. in 1983.

2. Each cell is typically sized at about 10 square miles.

3. Cell phones and base stations use low-power transmitters, thereby allowing the same frequencies can be reused in nonadjacent cells.

4. Most cell sites are powered by commercial power or generators at remote locations.

5. In 2012, 38% of U.S. households had only wireless phones, up to 41% in 2013.
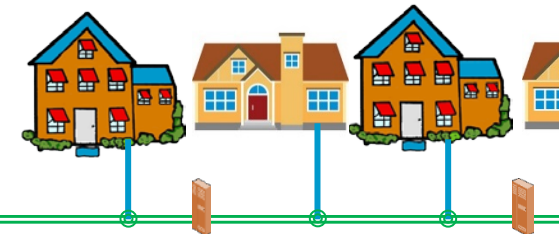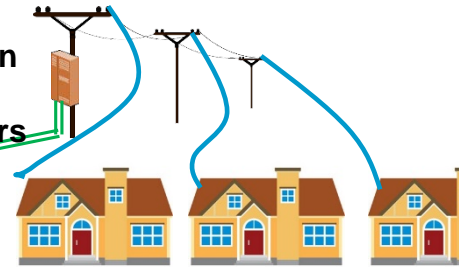
To Inter-Exchange Network

Fiber

Local Exchange

Main Exchange

Mobile Telephone Switching Office
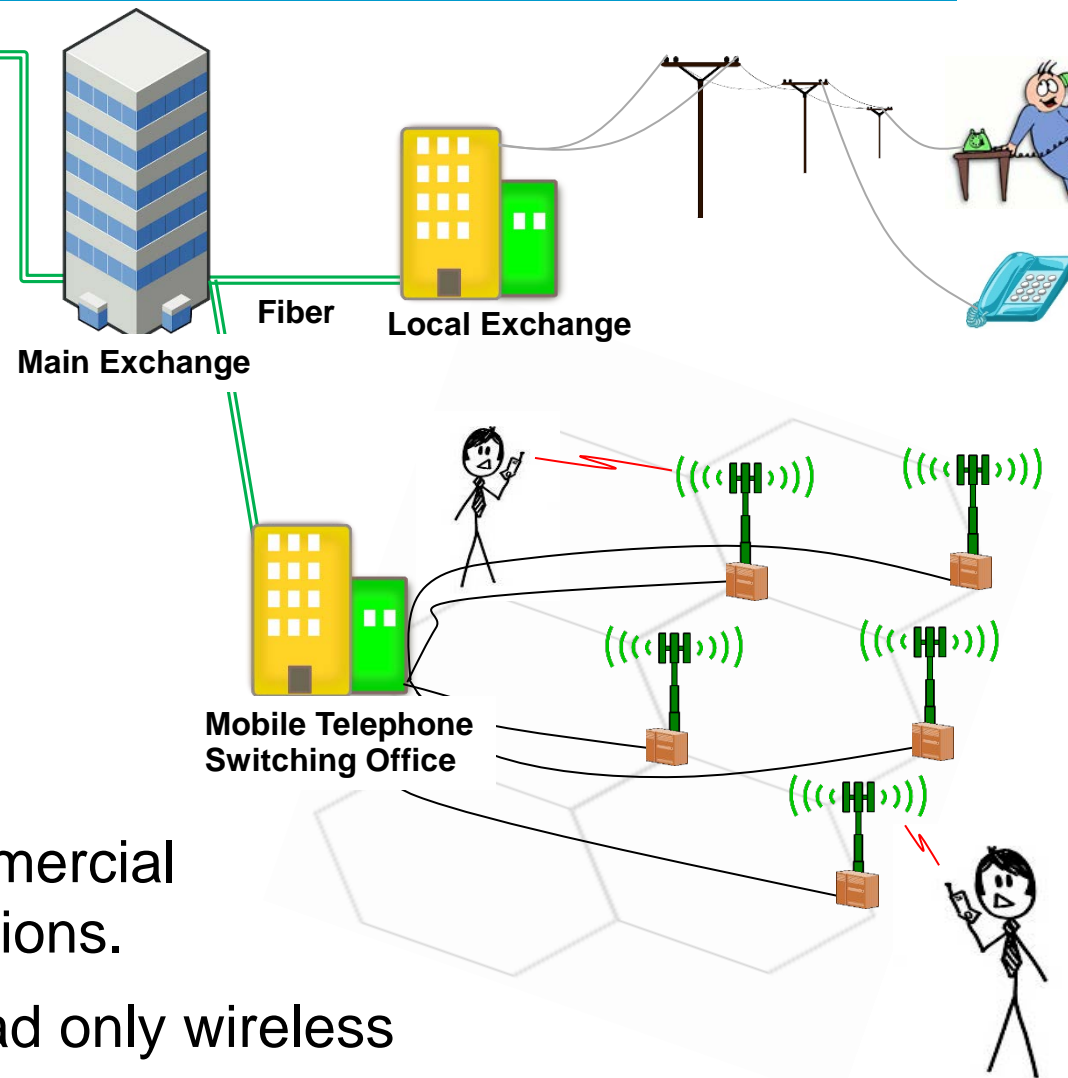
Digital Telephone, Cable Data Network

Comcast Regional Area Network,
Inter-exchange Network
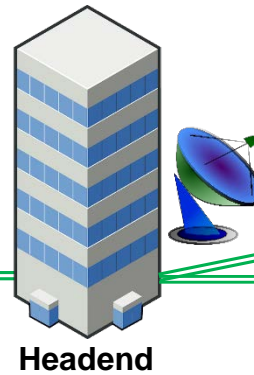
Distribution

Amplifiers

Headend

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. Uses the existing cable TV system for its delivery.

Distribution

Amplifiers

5. **Headend:** the master facility for receiving television signals for processing and distribution over a cable television system.

6. **Distribution Amplifiers:** ensures a sufficient signal level down the path.

7. **Coax Splitter:** splits signal for TV, Internet, and Phone.

Digital Telephone, DSL Data Network

To Inter-Exchange Network

VRAD

Central Office

Fiber to the Premises

1. AT&T broadband commercially launched in 2006.

2. Uses the existing telephone network.

3. Fiber-to-the-Premise: fiber to the home.

4. Fiber-to-the-Node; fiber to a VRAD, then twisted pair to the home.

5. **VRAD**: Video Ready Access Device; combines voice and data (DSLAM) with the TV stream to the home.

VRAD

**Fiber to the Node; Twisted Pair to the House**

DSLAM: Digital Subscriber Line Access Multiplexer; combines end voice and data traffic into one signal; at the Central Offices or VRADs.
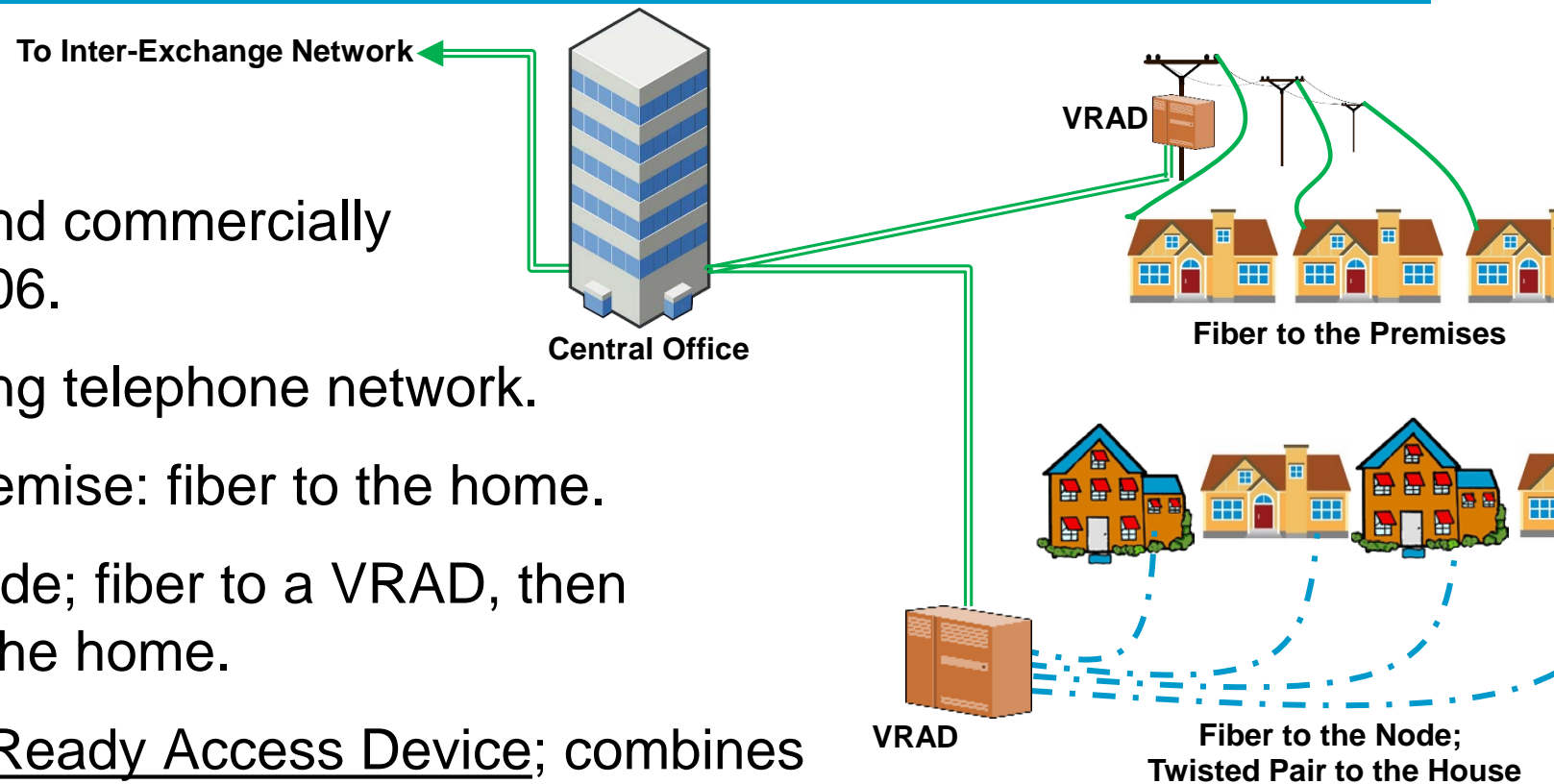
Telephone use… by the numbers
Who's using what?

- In 2012, the CDC estimated that only 38% of U.S. households had only wireless at home.

- Households with a **POTS-only wireline service** decreased from **88%** to **5%** between 2002 and 2012.
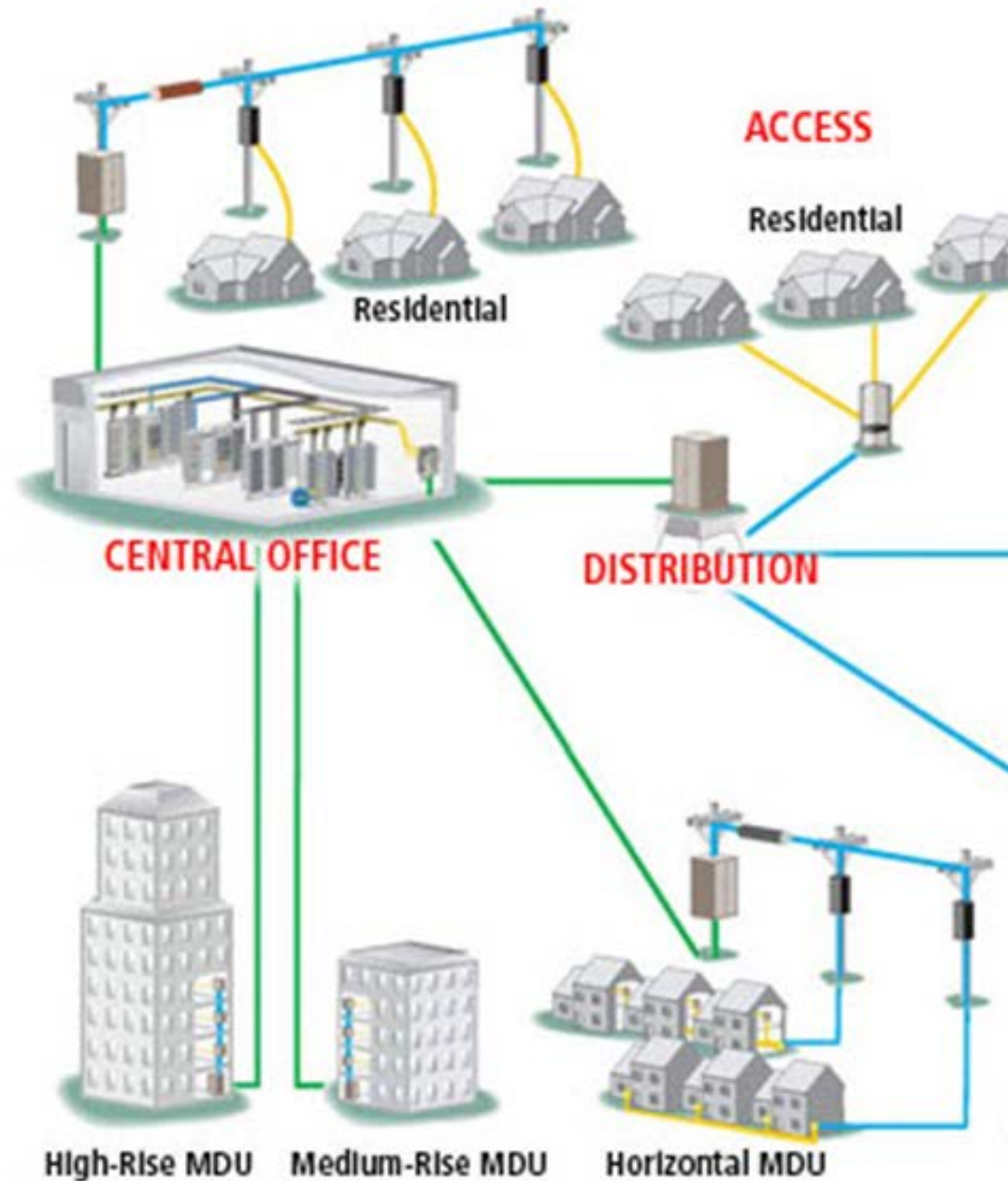

4%

29%

24%

5%

38%

- POTS+wireless
- POTS only
- wireless only
- VOIP+wireless
- VOIP only
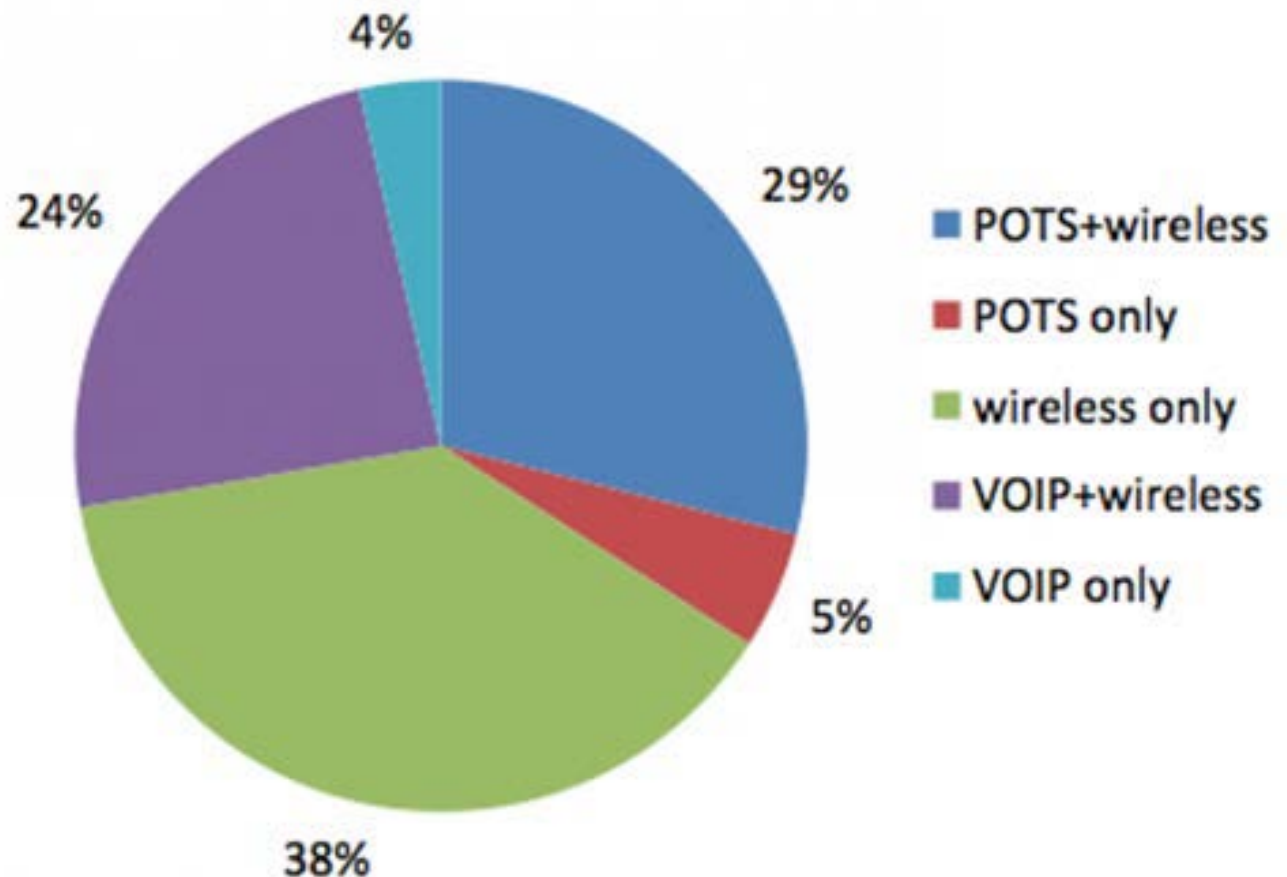
What do they all have in common?
Connectivity…

1. **Almost everything connects together**

   …in 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

ACCESS

Residential

Residential

CENTRAL OFFICE

DISTRIBUTION

High-Rise MDU   Medium-Rise MDU   Horizontal MDU

What do they all have in common?
…and Power

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.

Analog Phone

Wall socket

Telephone exchange
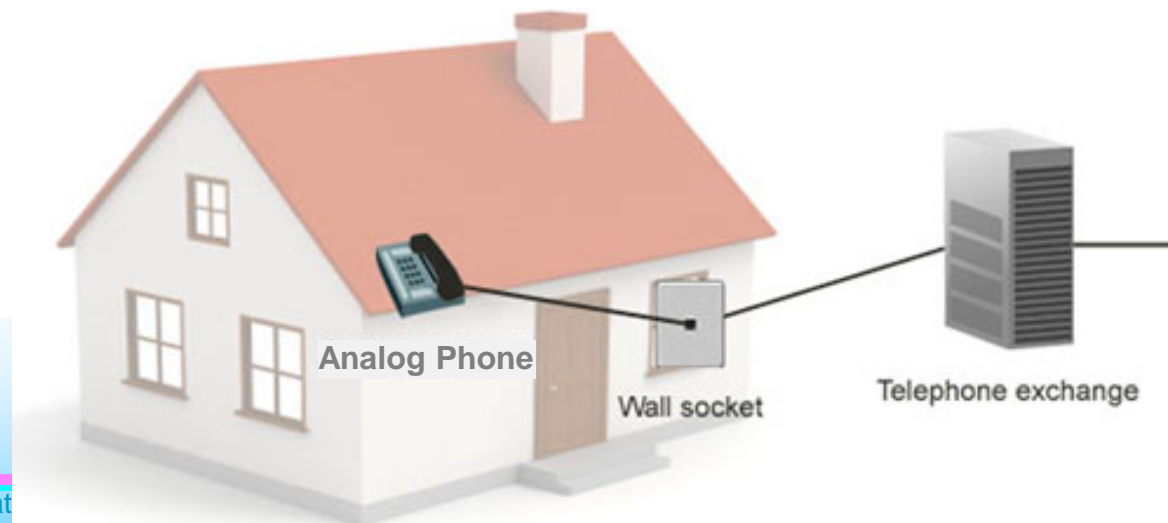
What do they all have in common?
...and Power

2. **All require power to operate**

   Cellular Telephone Network

   1. Towers, controllers fed from commercial power.

   2. Backup batteries are built into most standard power systems.

   3. Batteries can last from 2 to 8 hours, depending on their configuration.

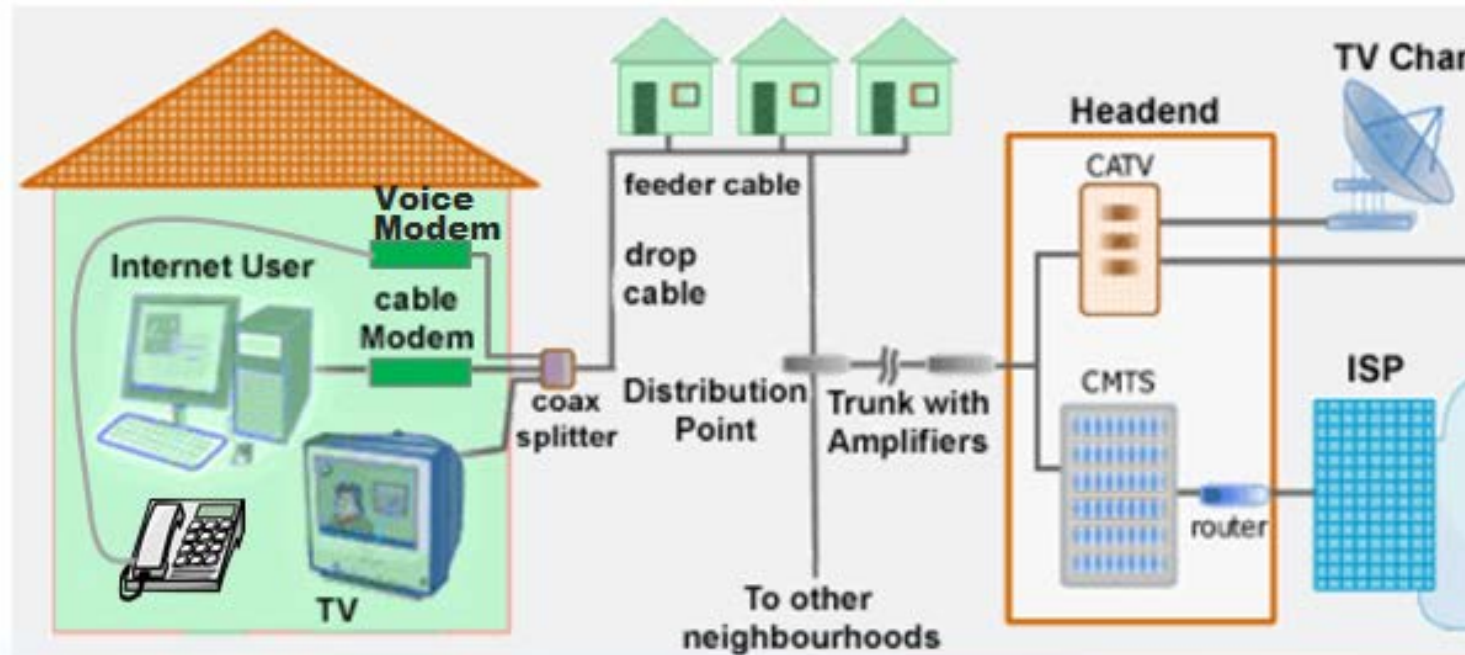   4. Generators are also used to avoid service interruption.

What do they all have in common?
…and Power

2. All require power to operate

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.
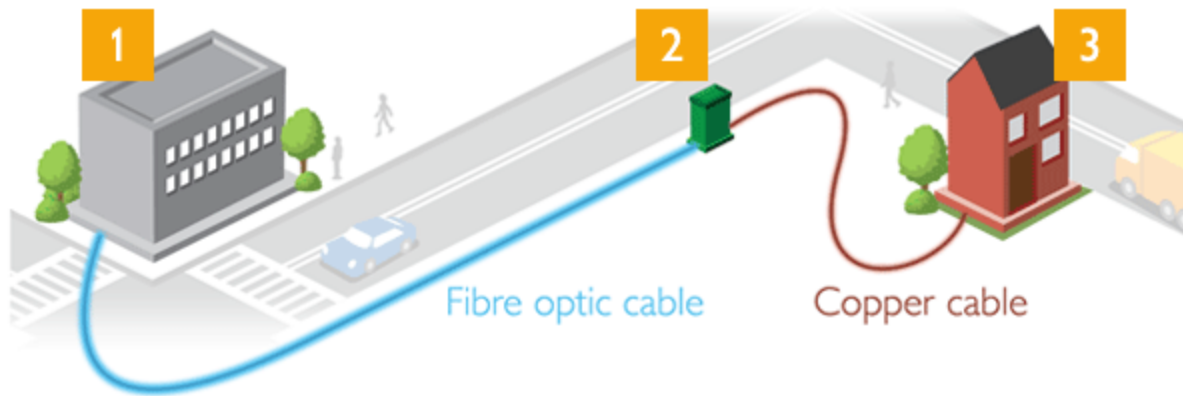
What do they all have in common?
…and Power

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

Fibre optic cable   Copper cable

1. Central Office: gen & battery backup.

2. VRAD Neighborhood boxes; backup NiMH batteries, 2-4 days of power.

3. Wi-Fi Resident Gateway; with phone service, add a Belkin 12V, 7Ah SLA.

What could cause communications outages?

- **Loss of Power**
  - Power failures – accidental, natural, intentional

- **Loss of Connectivity**
  - Cable breaks – accidental, natural, intentional

- **System Overload**
  - Some out-of-the-ordinary event that causes a lot of people to use the phone at the same time

- **Solar Storms, Solar Flares**

Is this scenario likely?
Loss of Power

Date	Event	Duration	Impact
Accidental			
November 1965	Northeast Blackout	13 hours	30,000,000
October 2003	Northeast Blackout	1-2 days	55,000,000
September 2011	Pacific Southwest	12 hours	7,000,000
Natural…			
October 1989	Loma Prieta Earthquake	2-3 days	1,400,000
January 1994	Northridge Earthquake	1 week	300,000
September 2005	Katrina	Weeks	3,900,000
Intentional…			
April 2013	Metcalf Sniper Attack	27 days	None

Is this scenario likely?
Loss of Power

Intentional

April 16, 2013, San Jose Mercury, *WSJ*. **Assault on California Power Station Raises Alarm on Potential for Terrorism.**

- telephone cables were cut.
- 20 minutes of shooting at the Station.
- 17 transformers were knocked out.
- 27 days to make repairs.

"If it was widely replicated across the country, [an event like this] 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
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

Sources: PG&E; Santa Clara County Sheriff's Dept.; California Independent System Operator; California The Wall Street Journal
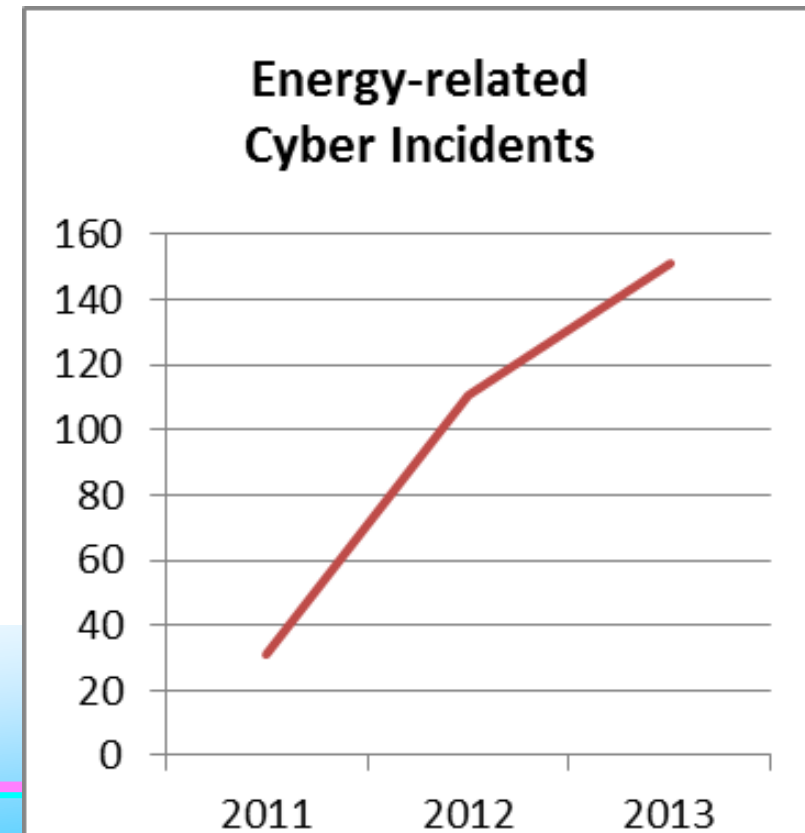
Is this scenario likely?
Loss of Power

Intentional – Other Reports

- Parts of the U.S. power grid are attacked online or in person every four days (per 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.

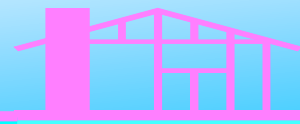- Department of Homeland Security was alerted to 151 energy-related "cyber incidents" in 2013, up from 31 in 2011 and 111 in 2012.

Energy-related Cyber Incidents

Is this scenario likely?

What <u>has caused</u> communications outages?
Loss of Connectivity

Accidental – in the news

- *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.

- *2013, Washington.* Underwater fiber-optic cable snapped leaving residents on the San Juan Islands without Internet and telephone 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.

What <u>has caused</u> communications outages?
Loss of Connectivity

Intentional – in the news

- **September 3, 2015, CA North Coast.** Vandals cut AT&T fiber cable in Hopland disrupting Internet, landline and cellphone service.

- **July 15, 2015, San Joaquin County.** Fiber optic line intentionally cut causing 9-1-1 outages; 10 hour outage.

- *July 1, 2015, San Jose.* Break-in to an underground vault and vandals cut three fiber-optic cables belonging to Level 3 and Zayo.

- *June 30, 2015, Sacramento.* three major fiber cables connecting the region were cut; disrupts service to Sacramento, Rocklin; ~15 hour outage

- *February 2015, Arizona.* Vandals cut through an underground bundle of fiber-optic cables; ATMs were down, stores couldn't process credit cards, and 9-1-1 emergency service was unavailable. ~15 hour outage.

What <u>has caused</u> communications outages?
Loss of Connectivity

Intentional – in the news

- *April 2009, San Jose.* underground fiber-optic cables were cut knocking out landlines, cell, and Internet for 10,000's in Santa Clara, Santa Cruz and San Benito Counties.

What <u>has caused</u> communications outages?
Loss of Connectivity

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

What <u>has caused</u> communications outages?
Loss of Connectivity

Other Notes

- Companies deploy more than **10 million miles of fiber annually** in the U.S., **increase the risk** of damage from backhoes, trench-diggers and shovels.

- In 1995, U.S. Commerce Dept's NIST warned 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 outages on high-capacity fiber lines in the U.S. more than doubled from **221 in 2010 to 487 in 2014**.

- And… are these intentional cable cuts a *Test*?

What <u>could cause</u> communications outages?
System Overload

Natural (2 examples)

- July 30, 2008, Los Angeles. Magnitude 5.4 earthquake, San Bernardino County. **Cell phone lines were jammed** as people frantically made calls immediately after the jolt. CA OES urged Californians to free up the lines for emergency use. No damage was reported to the network infrastructure.

- August 23, 2011, Washington DC. Magnitude 5.8 earthquake struck central Virginia. **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.
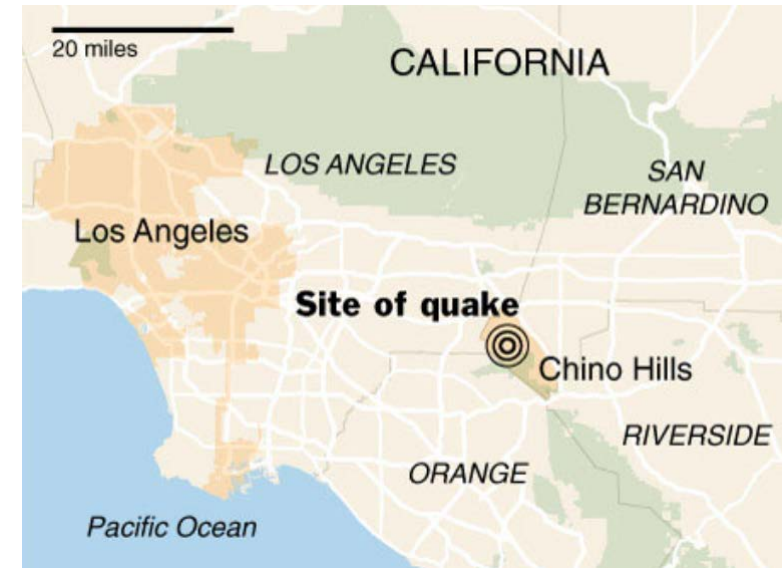
What <u>could cause</u> communications outages?
Solar Storms, Solar Flares

Date	Event	Duration	Impact
September 1859	Solar Storm (Carrington)	Unknown	Unknown
August 1972	Solar Flare, Illinois	Unknown	Unknown
March 1989	Solar Flare, Quebec	9 hours	6,000,000

- In 2012, NASA said the sun unleashed two massive plasma clouds that ***barely missed*** a catastrophic encounter with Earth.
  - "A direct strike could've caused widespread power outages and other damaging effects."
  - "If it had hit, we would still be picking up the pieces 2 years later."
  - NASA also cited research suggesting that there is a 12% chance of something like this happening in the next decade.

Takeaways

- Fewer fiber optic cable paths means wider impact when a cable break occurs.

- Intentional cable cuts are up.

- Cyber attacks on the power grid are also increasing.

- POTS will be gone within 5-10 years.

- Communications is growing more dependent on local rather than central power sources.

Managing Communications Risks

What can we control?

- City backup generators
- City 2-way radio systems
- AM TIS Station
- Ham Radio
- Local staff and volunteers

What can't we control?

- Power generation and distribution
- Landline (POTS) phone
- Cell telephone network
- Digital network

This implies that we should…

apply **Mitigations** here

apply **Contingencies** here
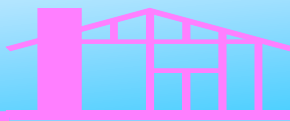
Assessing the Risks

Class 1: Unacceptable
- …in any circumstance.
- **7 Risks** related to City Hall Access, Loss of Power

Class 2: Undesirable
- Tolerable if the risk reduction is impracticable or costs are grossly disproportionate to the improvement gained.
- **9 Risks related to loss of residents' ability to dial 911**

Class 3: Tolerable
- …if the cost of risk reduction would exceed the improvement.
- **27 Risks** identified

Class 4: Acceptable
- …as it stands, though it may need to be monitored.
- None identified

Saturday early morning, 1:30am
Bay Area power outage

Almost 48 hours into the blackout.

- Wireline and cell phone communications fail throughout all of Santa Clara County.

- No dial tones were heard on picking up the telephone handset.

- Placing 911 calls is no longer possible.
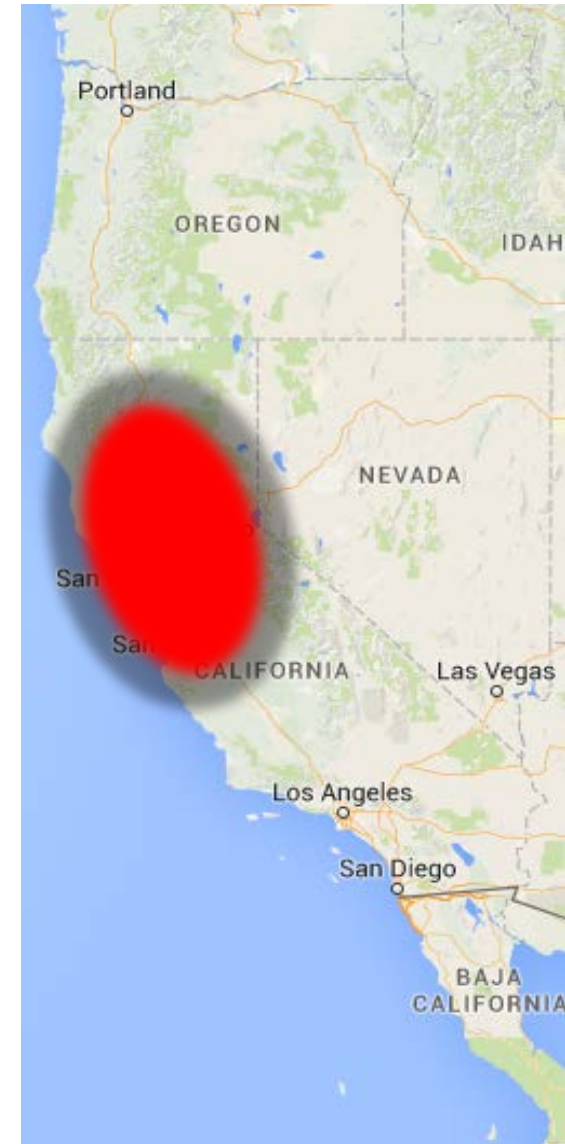
Saturday morning, 8:00am
Bay Area power outage

55 hours into the blackout.

- Activated CARES Emergency Net.

- Simulated an operator at County Comm; activated the "911" net.

- Deployed 10 CARES+CERT teams to staff field community emergency request stations.

- Used scripted event injects.

- Passed 52 messages over 2 hours; 26 to the EOC, 26 on the "911" net.

Debrief
Bay Area power outage

After Action Report Highlights

- Refine the deployment details and information handoffs with County Comm; involve other impacted cities.

- Re-do the Comm Outage Drill in May, this time by Packet.

- Check if County Comm's "manual mode" form is a candidate for PacFORMS.

www.cupertinoares.org

www.cupertinoares.org

CUP-15-26T, Communications Outage Exercise
November 21, 2015. What-if scenario: loss of power and communications
Communications Risk Report | Overview | Drill Prep | Exercise Plan | Injects | After
Action Report

CUP-15-24T, Cupertino Citizens Corp Field Exercise
October 17, 2015. Deploy CCC teams to assess specific areas in the City and report
to the Command Post

CUP-15-20T, ISA Exercise
May 16, 2015. Infrastructure Safety Assessment Exercise
Overview Part 1 | Overview Part 2 | Exercise Plan | After Action Report

CUP-15-10T, PSA Exercise
January 24, 2015. Annual Preliminary Safety Assessment Drill
Overview | After Action Report

CUP-14-25T, Field Packet Deployment
November 15, 2014. Full Packet Deployment; 6 Packet teams were deployed to 2
ARKs opened and staffed by CERT. CERT Staff also acted as the SIM CELL and
provided all message injects to the Packet Operators.
ARK Orientation | Exercise Plan | After Action Report

CUP-14-14T, Wildland Fire Exercise
May 17, 2014. This will be a communications functional exercise based on a wild
land fire event indirectly threatening the City.
Drought Overview | Drill Prep | Exercise Plan | Injects | After Action Report

Thank you!... Questions?

Anatomy of a Communications Outage