

# Making Broadband Internet Your Competitive Advantage

Understand **broadband transmission technologies**, from Frame Relay, ATM and DWDM, to copper, fiberoptics, and wireless. Evaluate **"last-mile" strategies**. Anticipate the ramifications and opportunities broadband Internet will bring. Explore how **instantaneous universal connectivity** could change your practice, and how it empowers **"single source"** and **"real-time enterprise"** to give you the ultimate productivity.

by

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# Bandwidth

- **Band = electromagnetic (EM) radiation spectrum: range of frequencies or wavelengths (in inverse relationship)**
  - radio waves > microwaves > infrared radiation > visible light > ultraviolet radiation > X rays > gamma rays
  - all travel at 186,282 miles/second (in vacuum)
- **Hertz ~ frequency: number of cycles of change per second**
- **Very low frequency band (~ long wavelength: 3-30 kHz) to extremely high frequency band (~ short wavelength: 30-300 GHz)**
  - voice: ~ 3 kHz; TV: ~ 6 MHz; cellular 824-849 MHz; PCS 1850-1990 MHz
- **Broadband: a wide band (channels ~ "more lanes on a highway") of frequencies is available to transmit data (=> 200 Kbps)**

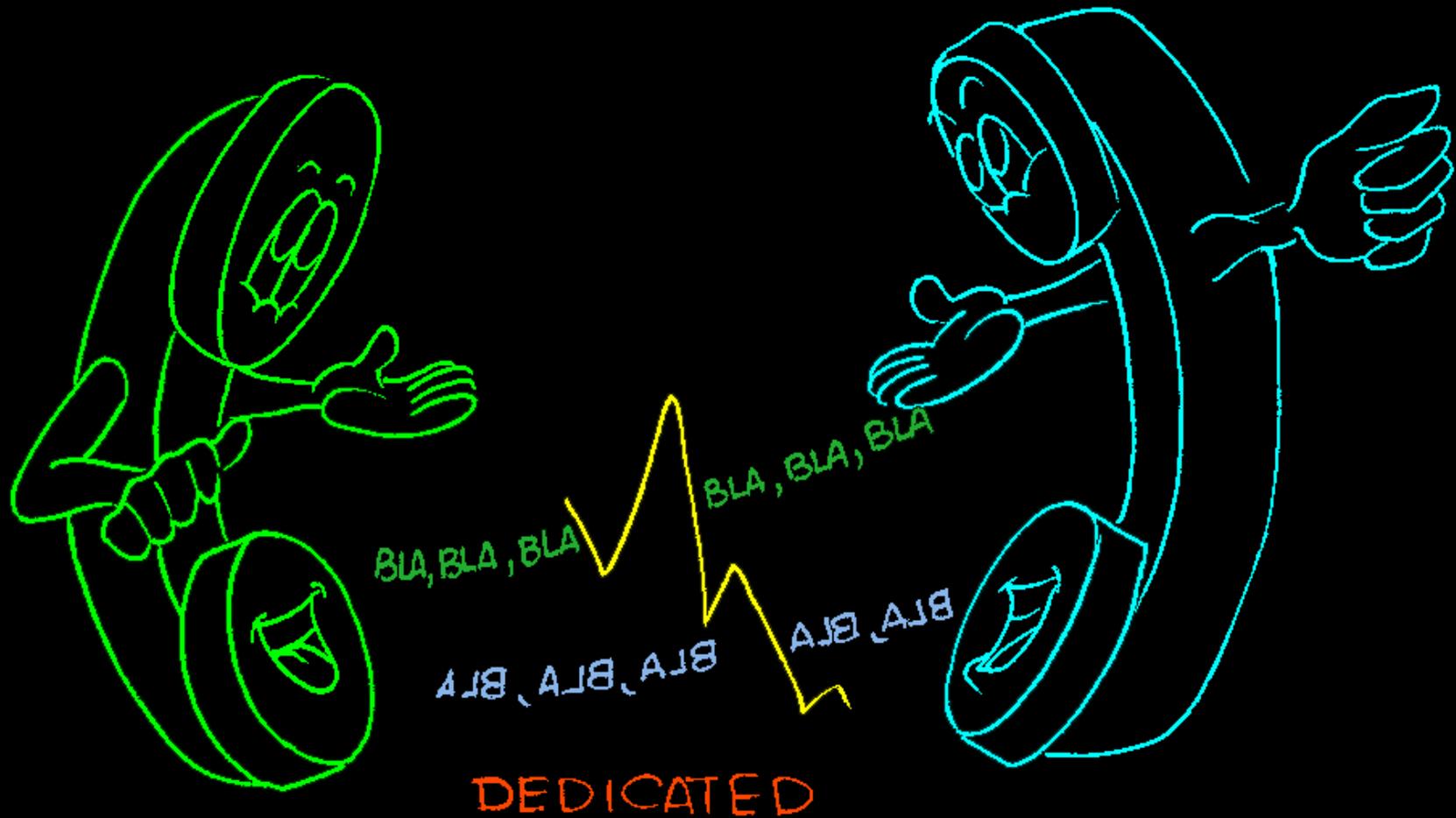
# Digital Signal Processing (DSP)

- **Amplify/clarify/standardize levels/states of signals; remove extraneous noise**
- **Analog-to-digital converter (ADC):**
  - audio frequencies sampled 8,000 times a second, each digitized into 8-bit word
- **Digital-to-analog converter (DAC):**
  - 8-bit words converted into frequencies

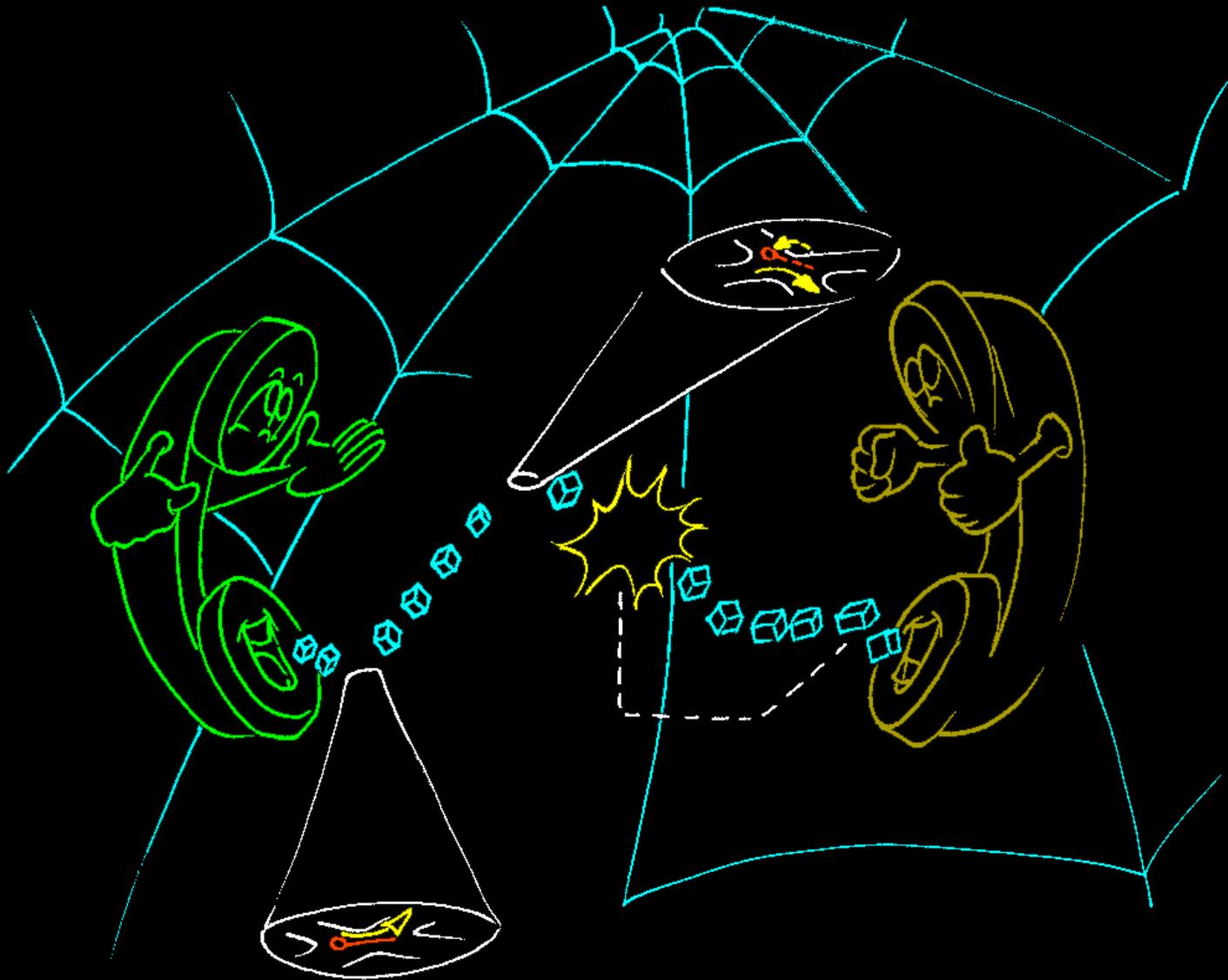
# LEC/ILEC/CLEC .. BOC/RBOC

- **Local Exchange Carriers (LECs)** or public telephone companies (telcos) control "local loop" to customers
- LEC consists of **Regional Bell Operating Companies (RBOCs)** and their constituent BOCs
- **7 original RBOCs each owns at least 2 BOCs:**
  - Ameritech // Bell Atlantic // Bell South // NYNEX // Pacific Bell // Southwestern Bell // US West
- **Incumbent LECs (ILECs) = 4 current RBOCs (Baby Bells):**
  - Verizon (Bell Atlantic + GTE) // Bell South // SBC Communications (Southwestern Bell, Pacific Bell + Ameritech) // Qwest (+ US West)
- **Competitive LECs (CLECs):**
  - e.g., North American Telecom, Winstar Comm., AT&T, Worldcom
- LECs connect to LECs via **Interexchange Carriers (IXCs)**, aka long distance giants:
  - AT&T // Worldcom // Sprint // Qwest

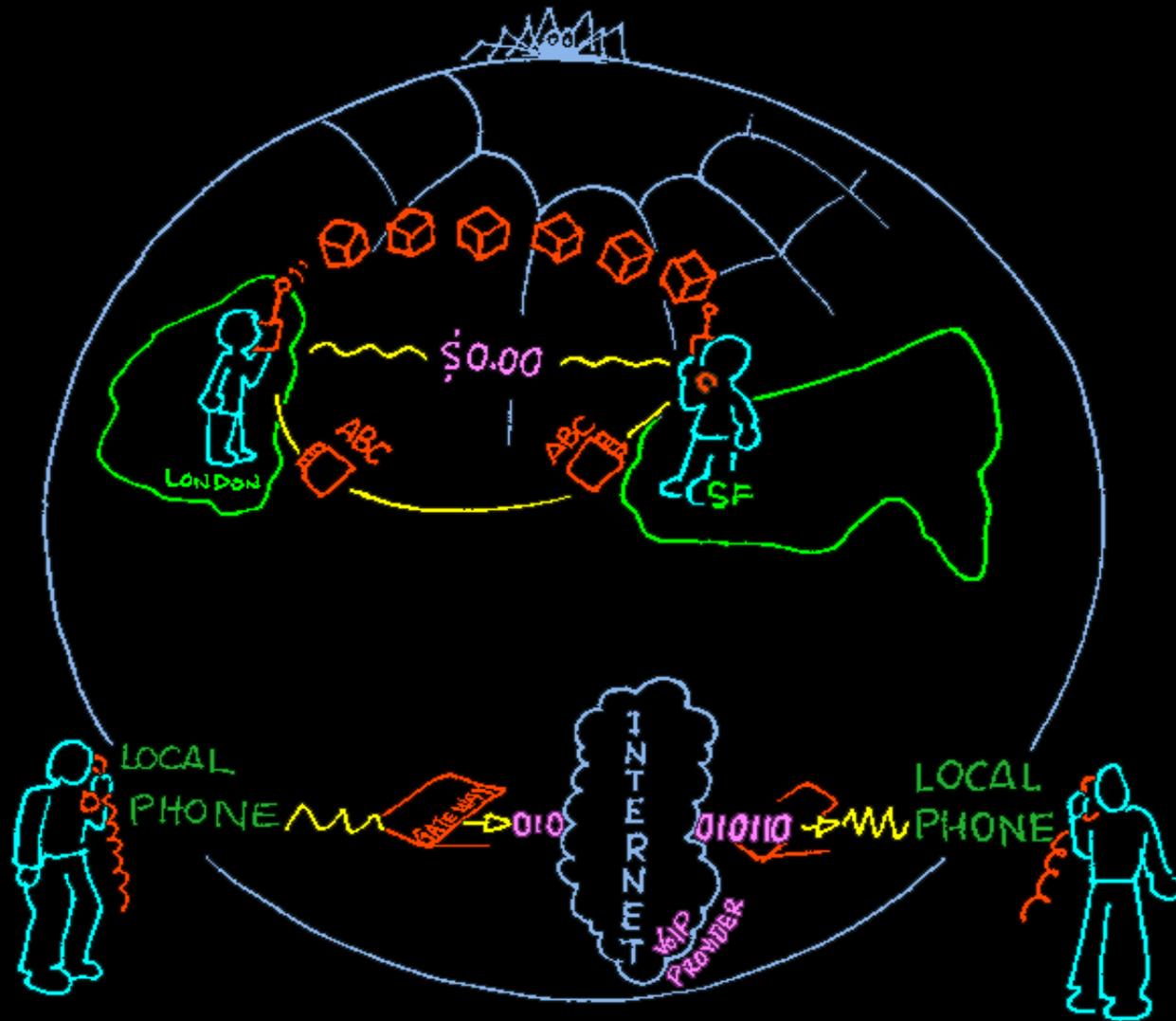
# Circuit Switching



# Packet Switching



# Voice Over IP (VoIP)



# Synchronous Optical NETWORK (SONET)

- **Carrier backbone:** average packet traverses U.S. coast-to-coast through 30 SONET devices and 15 routers
- **51.84 Mbps - 2.48 Gbps** (max. 9.953 Gbps; 20 Gbps line rate possible)
- **OCx (Optical Carrier Levels):**
  - OC-1: 51.84 Mbps (base rate)
  - OC-3: 155.52 (3 x 51.84)
  - OC-12: 622.08
  - OC-24: 1.244 Gbps
  - OC-48: 2.488
  - OC-192: 10
  - OC-256: 13.271
  - OC-768: 40 (DWDM)

# Asynchronous Transfer Mode (ATM)

- **Dedicated-connection switching technology**
- **53-byte cell units**
- **Hardware (vs. software) implementation**
- **155.52 Mbps or 622.08 Mbps (up to 10 Gbps)**

# T-Carrier System

## ● T1:

- dedicated, non-switched line to ISP
- 2 pairs of twisted pair: 2 wires sending; 2 wires receiving
- now: coaxial, optical fiber, digital microwave
  - 8-bit word x 8k times/second = 64 Kbps //
  - 24 channels x 64 = 1.544 Mbps

## ● T3:

- 672 channels x 64 = 44.736 Mbps (~30xT1)

# Frame Relay

- **Variable-size units (<1000 bytes) called frames**
- **Prioritized frames**
- **Error correction at receiving ends**
- **56 Kbps - 1.544 Mbps**
- **Permanent Virtual Circuit (PVC):**
  - Bandwidth-on-demand vs. leased T-1**
  - dedicated logical connection**
  - reserved path on an ongoing basis**
  - actual physical resources shared among multiple logical connections or users**

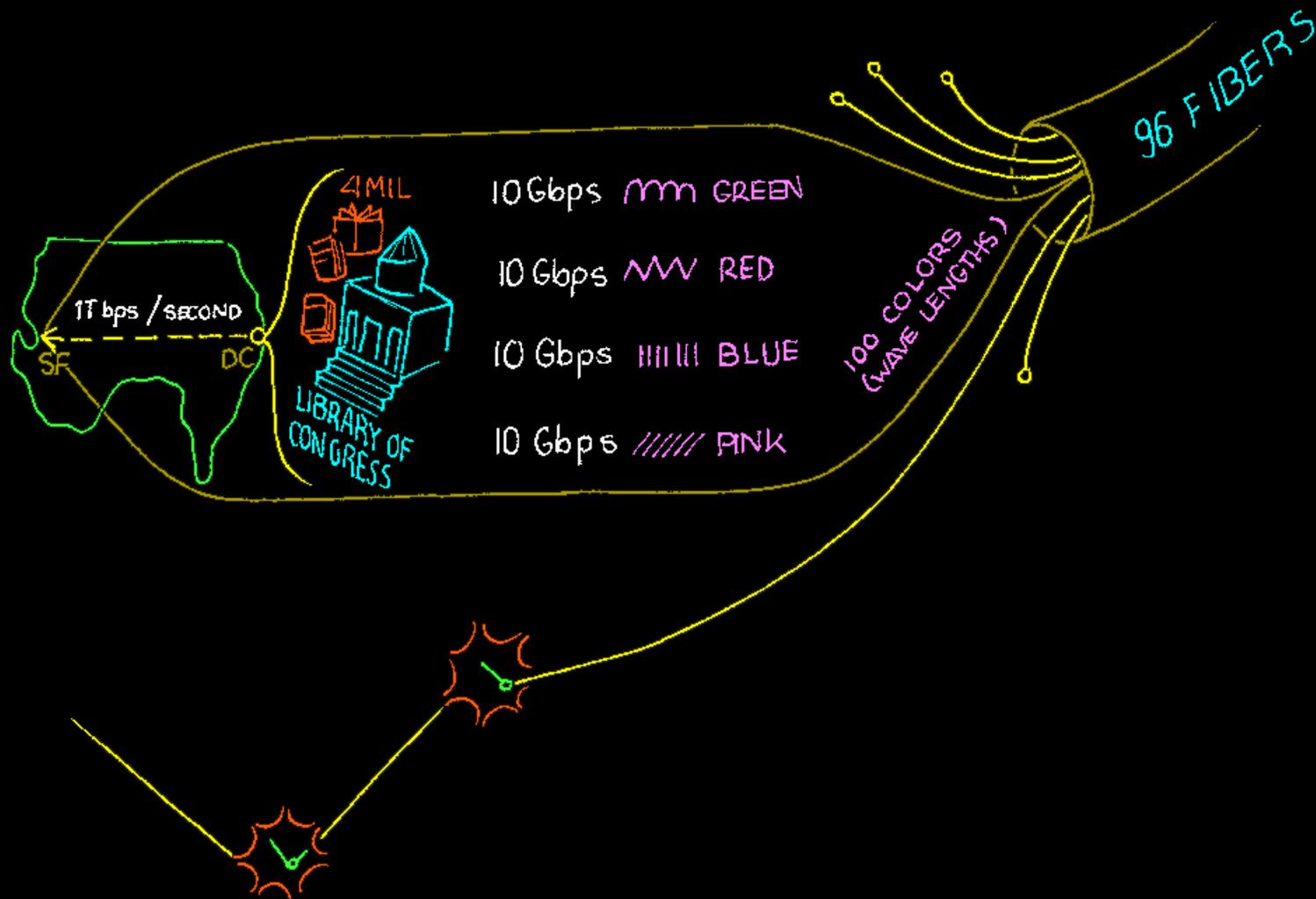
# Ethernet

- **Coaxial cable or special-grade twisted pair**
  - devices compete for access: Carrier Sense Multiple Access with Collision Detection (CSMA/CA) protocol
- **10BASE-T (IEEE 802.3)**
  - 10 = 10 Mbps
  - BASE = baseband signaling: only Ethernet signals are carried
  - T = Twisted pair (CAT 3)
- **Fast Ethernet: 100BASE-T (CAT 5 unshielded twisted pair)**
- **Gigabit Ethernet: 1000BASE-T (on 4 pairs of CAT 5)**
- **10-Gigabit Ethernet: on optical fiber**
  - ~ replacement of ATM & SONET

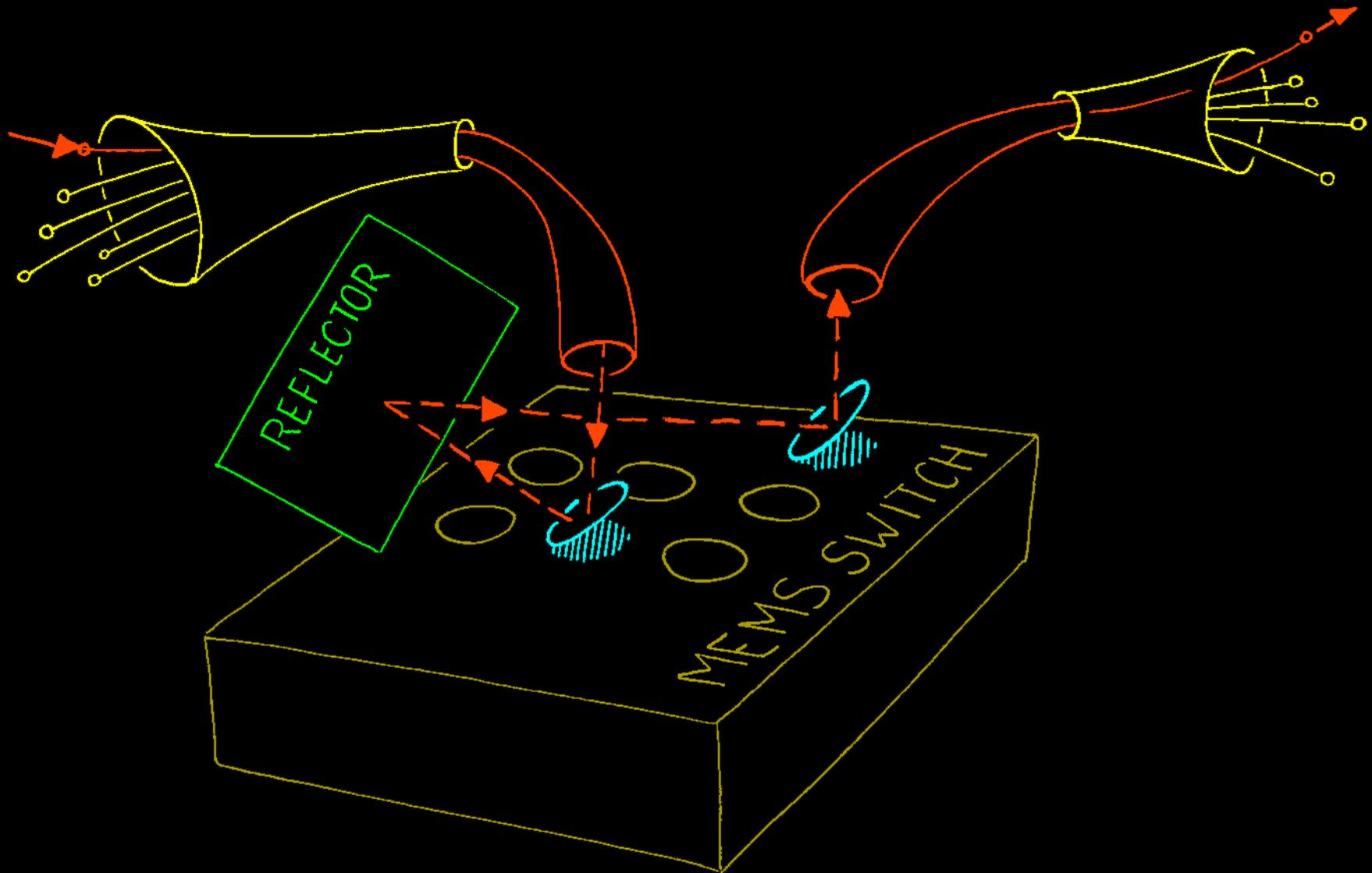
# Optical Fiber

- Frequencies of visible light or infrared (IR) energy = millions of MHz: millions of signals impressed onto a single beam by **frequency division multiplexing (FDM)**
- IP, SONET, ATM on same optical fiber: different data formats transmitted at different data rates
- **Erbium-doped fiber amplifier (EDFA)**: amplifies a modulated laser beam directly w/o **opto-electronic** and **electro-optical** conversion at ~100 km
- **Fiber to the curb (FTTC)**: curb to PC via coaxial cable
- **Fiber to the building (FTTB) // Fiber to the home (FTTH)**

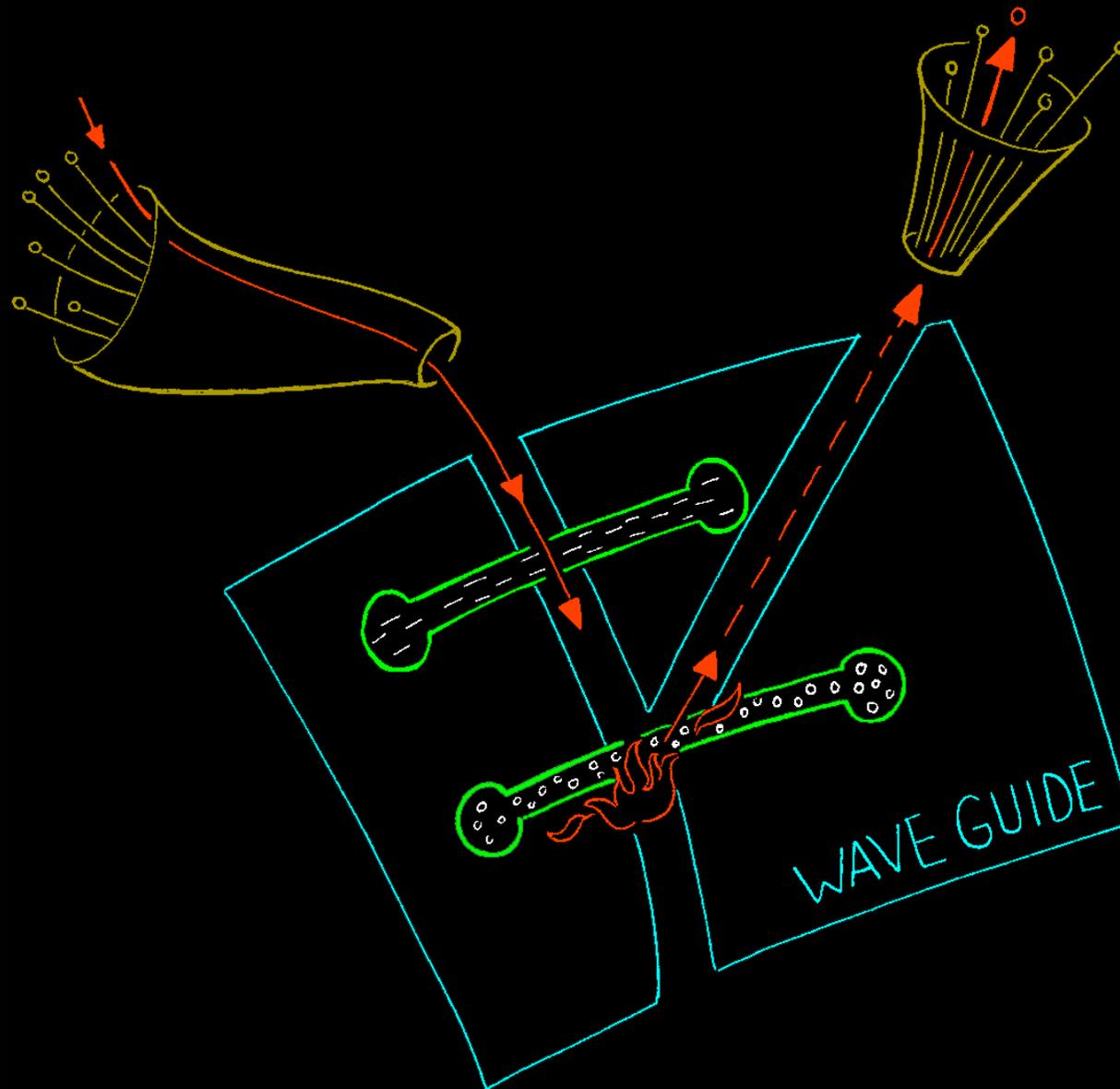
# Dense Wavelength Division Multiplexing (DWDM)



# MEMS Optical Switch



# Bubble Jet Optical Switches



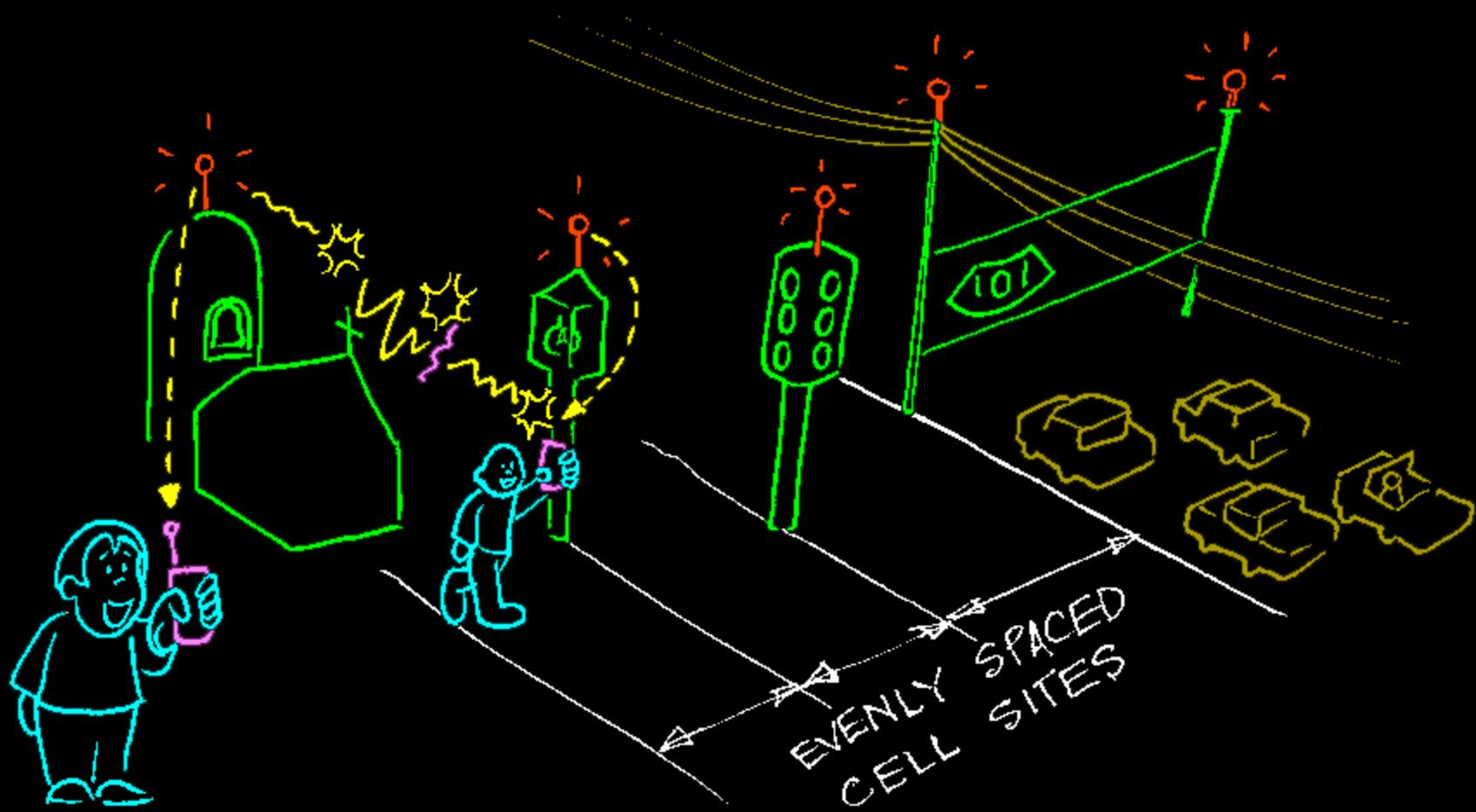
# Wireless Speeds

- **1G: Cellular mobile radio telephone; late 1970s-1980s**
- **2G: ~ Global System for Mobile (GSM) Communications; 15 Kbps (typical 9.6); 1990-2003**
- **2.5G: General Packet Radio Services (GPRS); 28 Kbps (max. 114); 2001-2003**
  - AT&T Wireless, Cingular Wireless, Voicestream Wireless, Nextel Comm.
- **3G: ~ Universal Mobile Telecommunication Service (UMTS); 384 Kbps (wide area) - 2 Mbps (local area); 2003-2005**
  - Sprint PCS, Verizon Wireless

# Wireless Devices

- Cellular phones
- Cordless telephone sets
- Pagers
- Global Positioning System (GPS)
- Wireless LAN
- Cordless computer peripherals:
  - printer / fax / keyboard / mouse / monitor
- Home-entertainment-system control boxes
  - video disc recorder (VDR) / TV / intercom system
- Satellite TV
- Remote garage-door openers
- Two-way radios
- Baby monitors

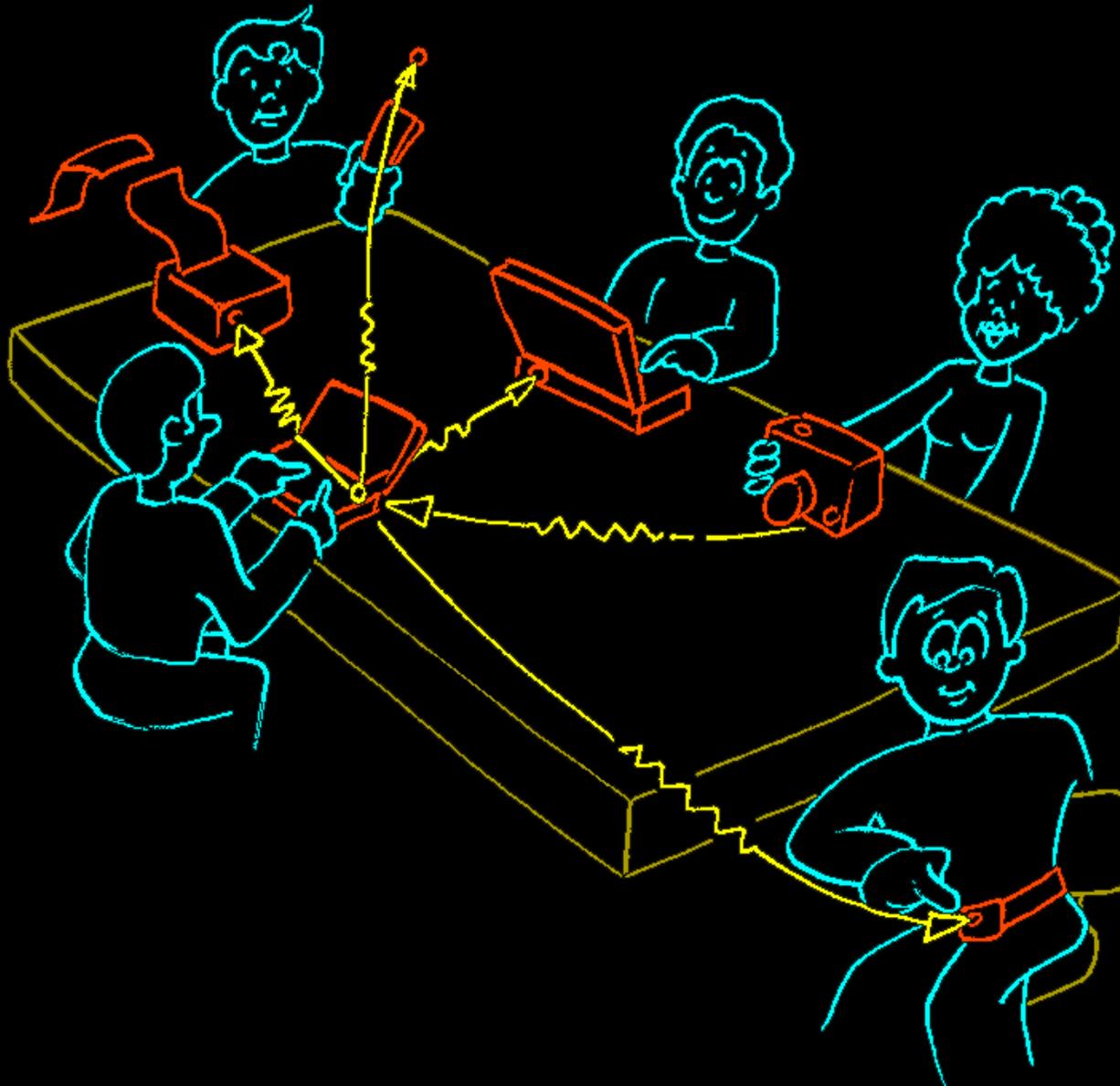
# Personal Communication System (PCS)



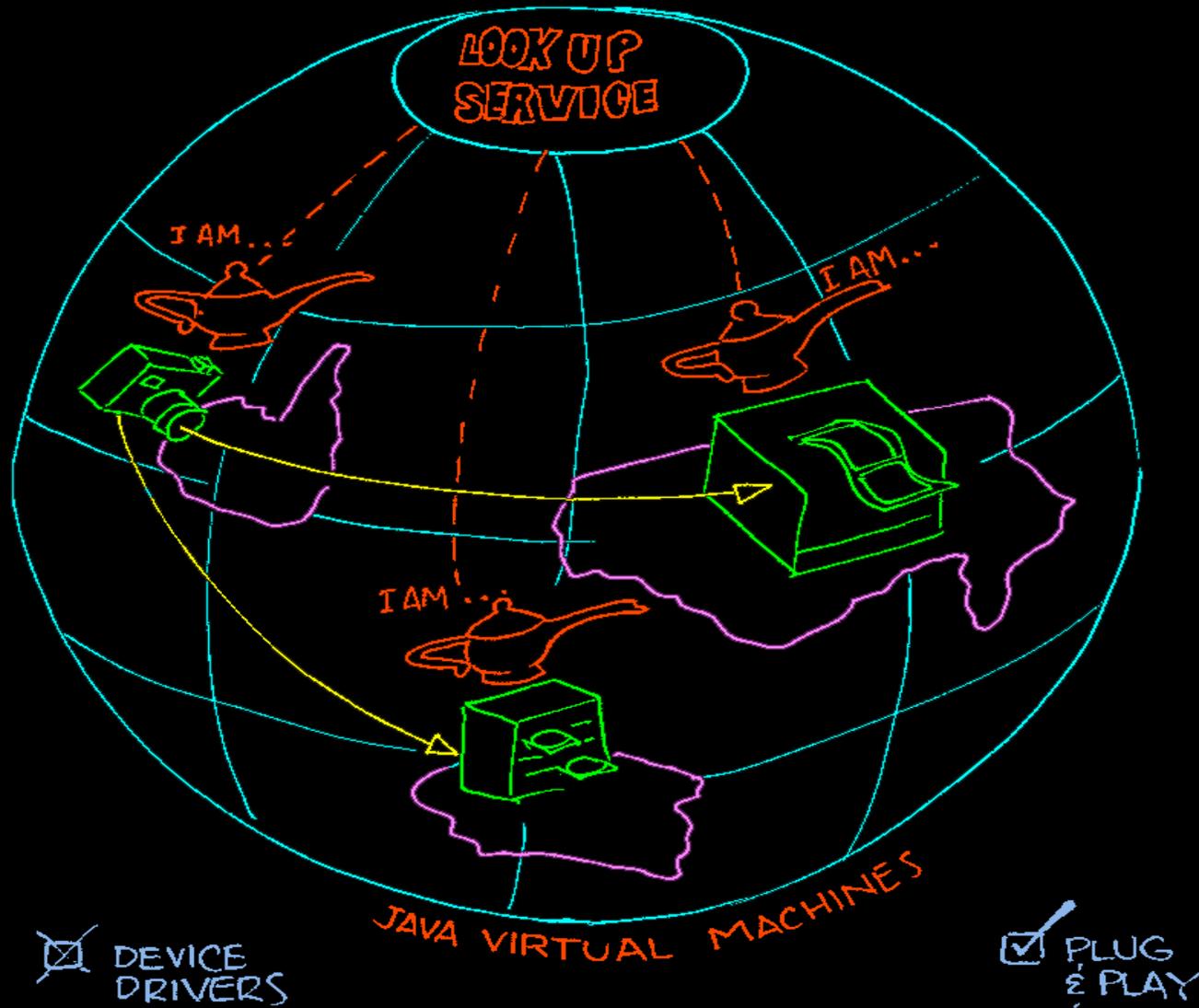
# Wi-Fi (Wireless Fidelity)

- **Wi-Fi = Wireless Ethernet = Wireless LAN = 802.11b protocol**
  - Access point: connected to wired Internet (~>\$100)
  - Wireless access PC card (~>\$80)
  - ~150' thru walls; 300'-900' open space
- **802.11b: 2.4 GHz; up to 11 Mbps (current)**
- **802.11a (Wi-Fi5): 5 GHz; 20-54 (Mid 2002)**
- **802.11g: 2.4 GHz; 20-54**

# Bluetooth



# Jini: Spontaneous Networking



# Last/First Mile Technologies

- **Integrated Services Digital Network (ISDN)**
- **Cable Modem**
- **Digital Subscriber Line (DSL)**
- **Wireless**
- **Satellite**
- **Optical Fiber**

# Integrated Services Digital Network (ISDN)

- **Terminal adapter (vs. modem) at phone company and customer site**
  - analog (voice) data and digital data on same line
- **Basic Rate (128 Kbps):**
  - 2/64 Kbps B-channels: data, voice
  - 1/16 Kbps D-channel: control and signaling information
- **Primary Rate (Mbps):**
  - 23 B-channels
  - 1/64 Kbps D-channel

# Cable Modem

- **Downstream 1.5 Mbps (up to 27 Mbps)**
- **Upstream capped at 128 Kbps (up to 2.5 Mbps)**
- **Coaxial cable: 1 physical channel surrounded by insulation, then outer channel as ground**
- **Connected to wall outlet, and PC or set-top box for TV**
- **Standard 10BASE-T Ethernet card in computer**

# Cable Modem Providers

- **AT&T Broadband \***
- **Time Warner Cable**
- **Comcast Corp. \***
- **Charter Communications**
- **Cox Communications**
- **Adelphia**
- **@Home (bankrupted)**

# Digital Subscriber Line (DSL)

- **Max. 18,000 ft. (5.5 km)**
- **Signal splitter:** incoming signals into low frequencies (voice) and high frequencies (data)
- **Asymmetric DSL (ADSL):** splitting at customer site
  - 1.544-6.1 Mbps downstream / 16-640 Kbps upstream
- **Splitterless DSL = DSL Lite = G.Lite = Universal ADSL:** splitting from central office
  - 1.544-6.1 Mbps downstream / 128-384 Kbps upstream
- **Very high rate DSL (VDSL):** ATM; fiber to the neighborhood (FTN)
  - 12.9-52.8 Mbps downstream / 1.5-2.3 Mbps upstream

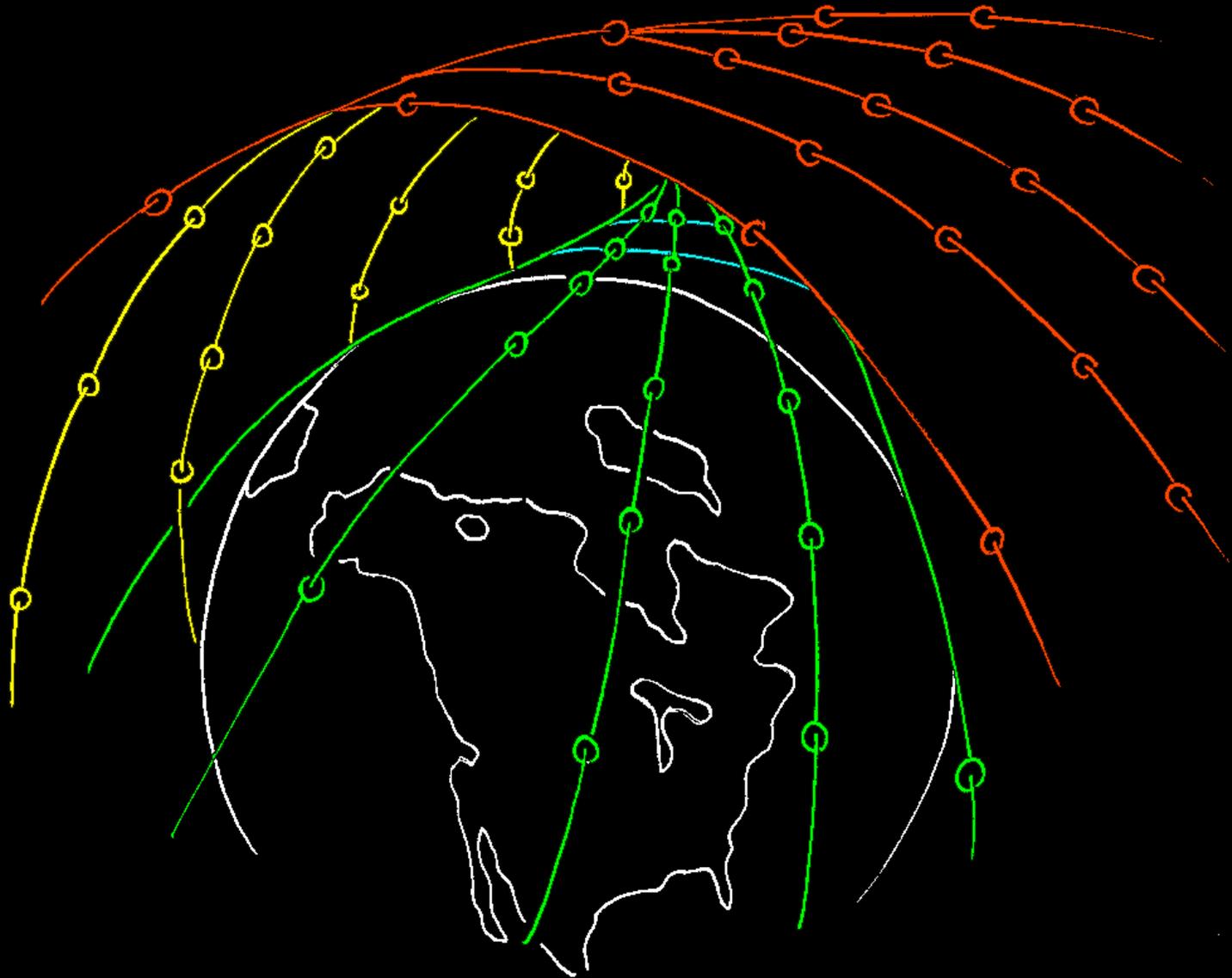
# DSL Providers

- **SBC Communications**
- **Verizon:**
  - **640 Kbps (down) / 90 (up) ~ \$59.95**
  - **1.6 Mbps / 90 Kbps ~ \$109.95**
  - **7.1 Mbps / 680 Kbps ~ \$189.95**
- **Bell South**
- **Qwest**
- **Covad (re-emerged from Chapter 11)**

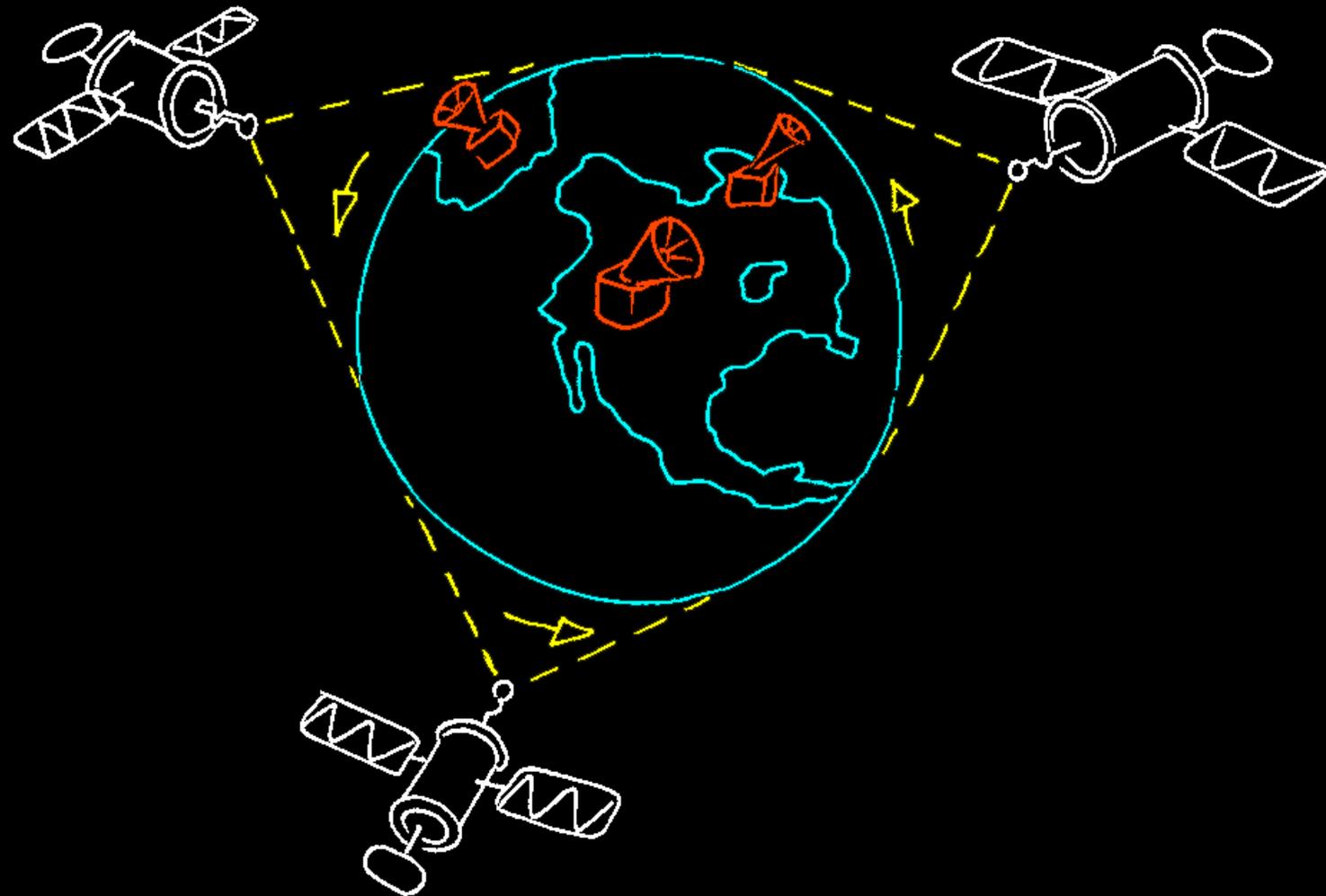
# Free-Space Optics (FSO)

- = Free-space photonics (FSP) = fiberless optics
- Light waves sent through space: point to multipoint
  - non-regulated frequencies
  - visible or infrared (IR) beam through atmosphere
  - laser beams
  - non-laser sources such as light-emitting diodes (LEDs) or IR-emitting diodes (IREDs)
  - lenses or mirrors to go farther or change direction
- **Concerns:** rain, dust, snow, fog or smog; clear line of sight required

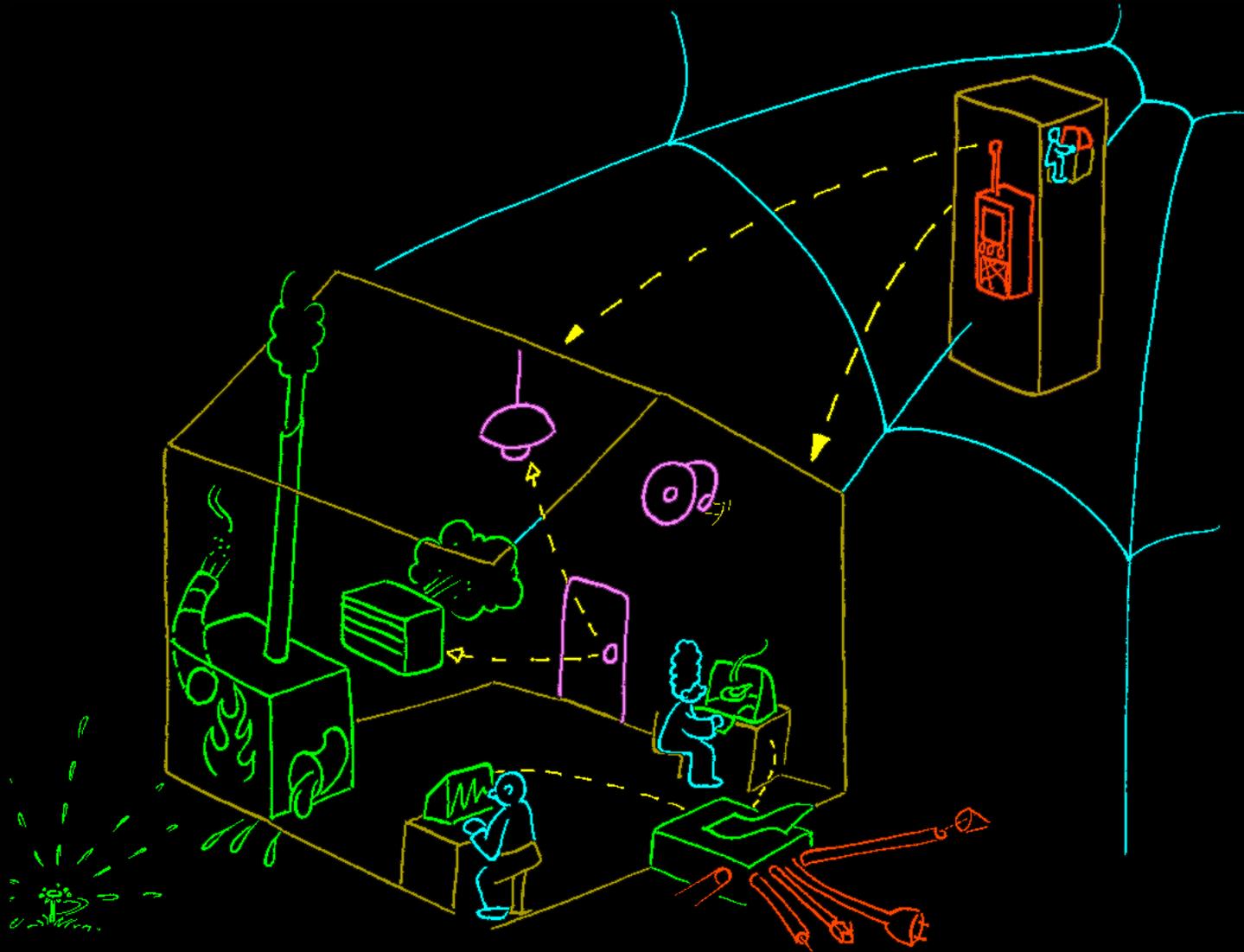
# Low Earth Orbit Satellites (LEOs)



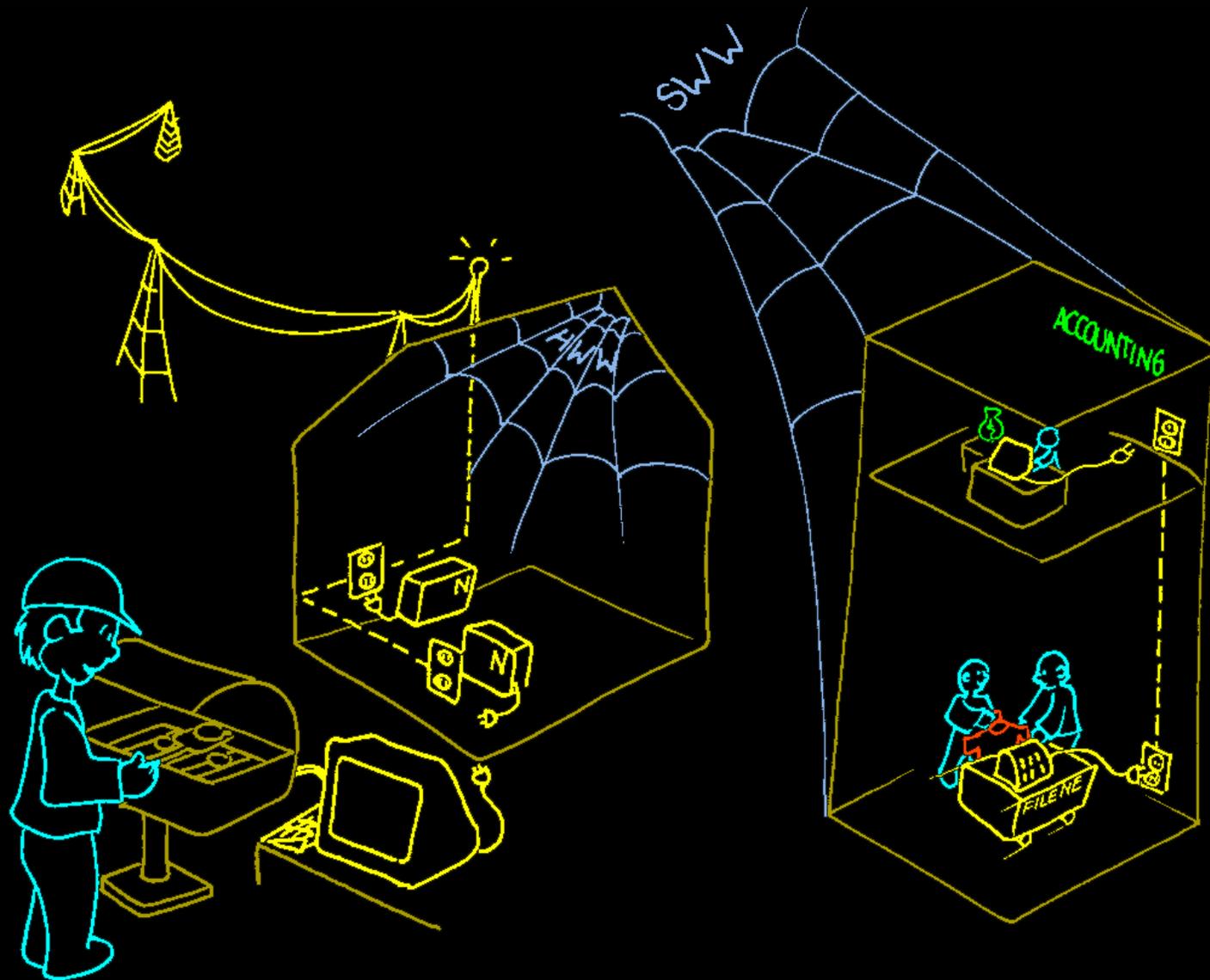
# Geostationary & Geosynchronous Satellites (GEO)



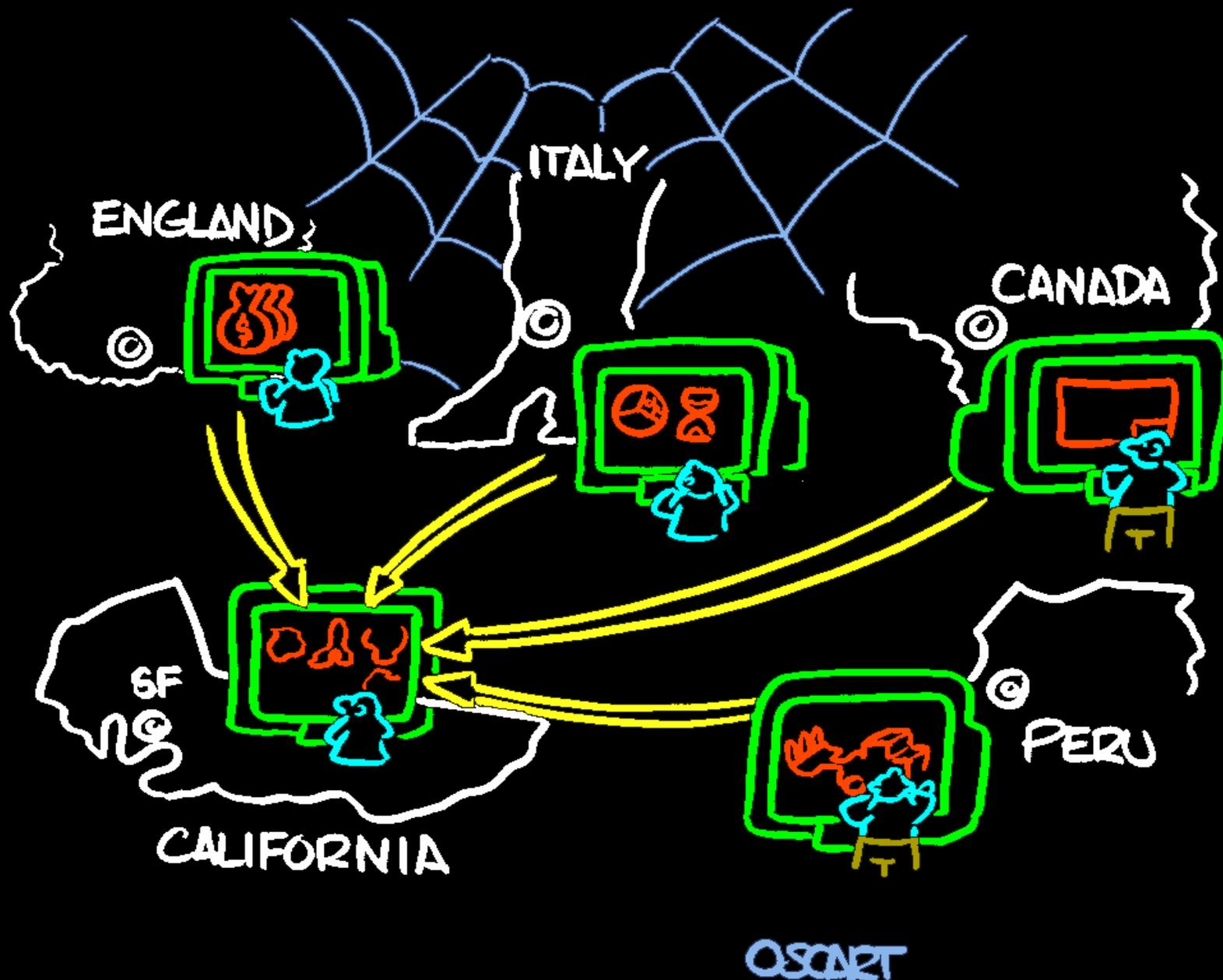
# Home Network



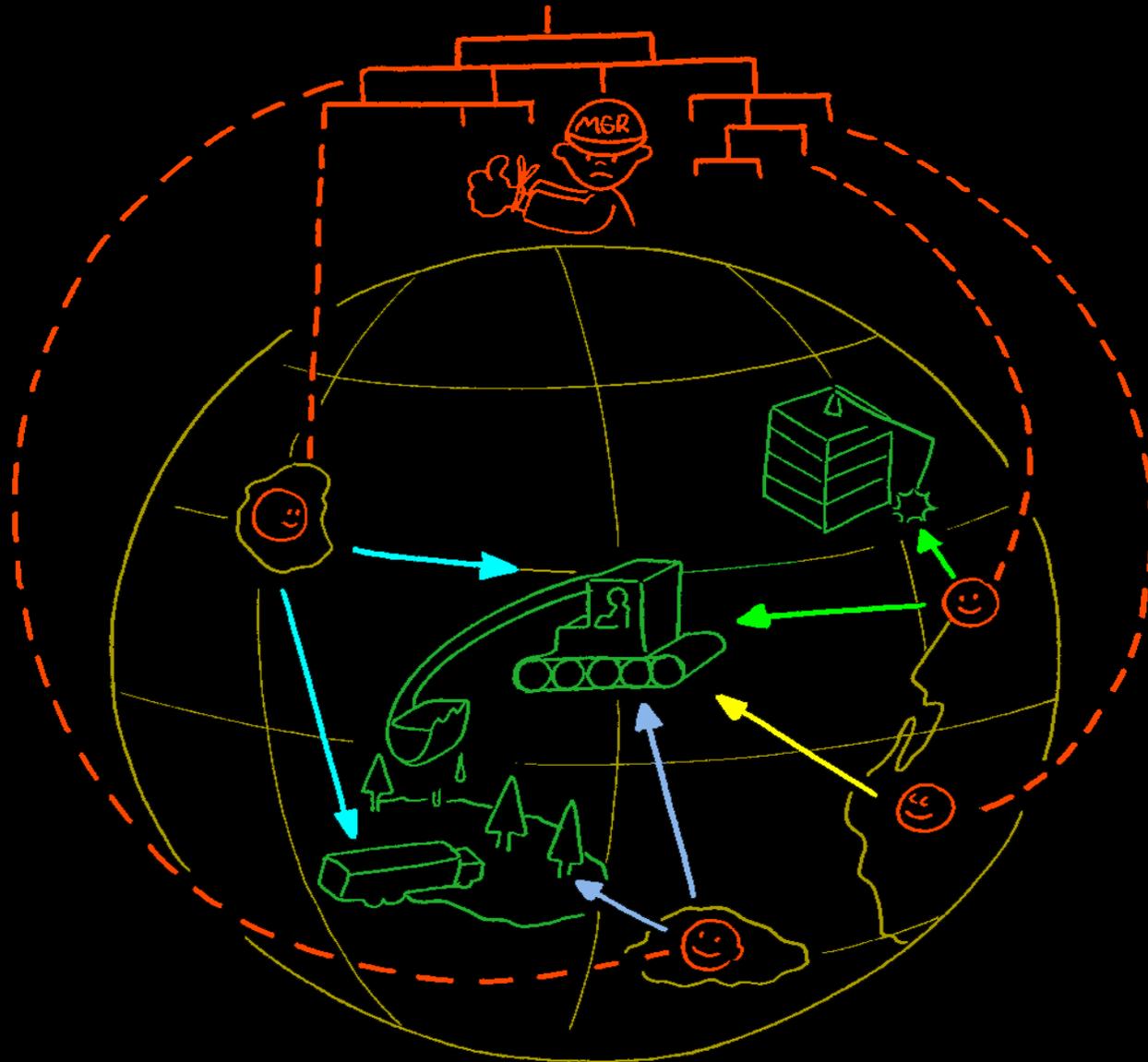
# Digital Power Line (DPL)



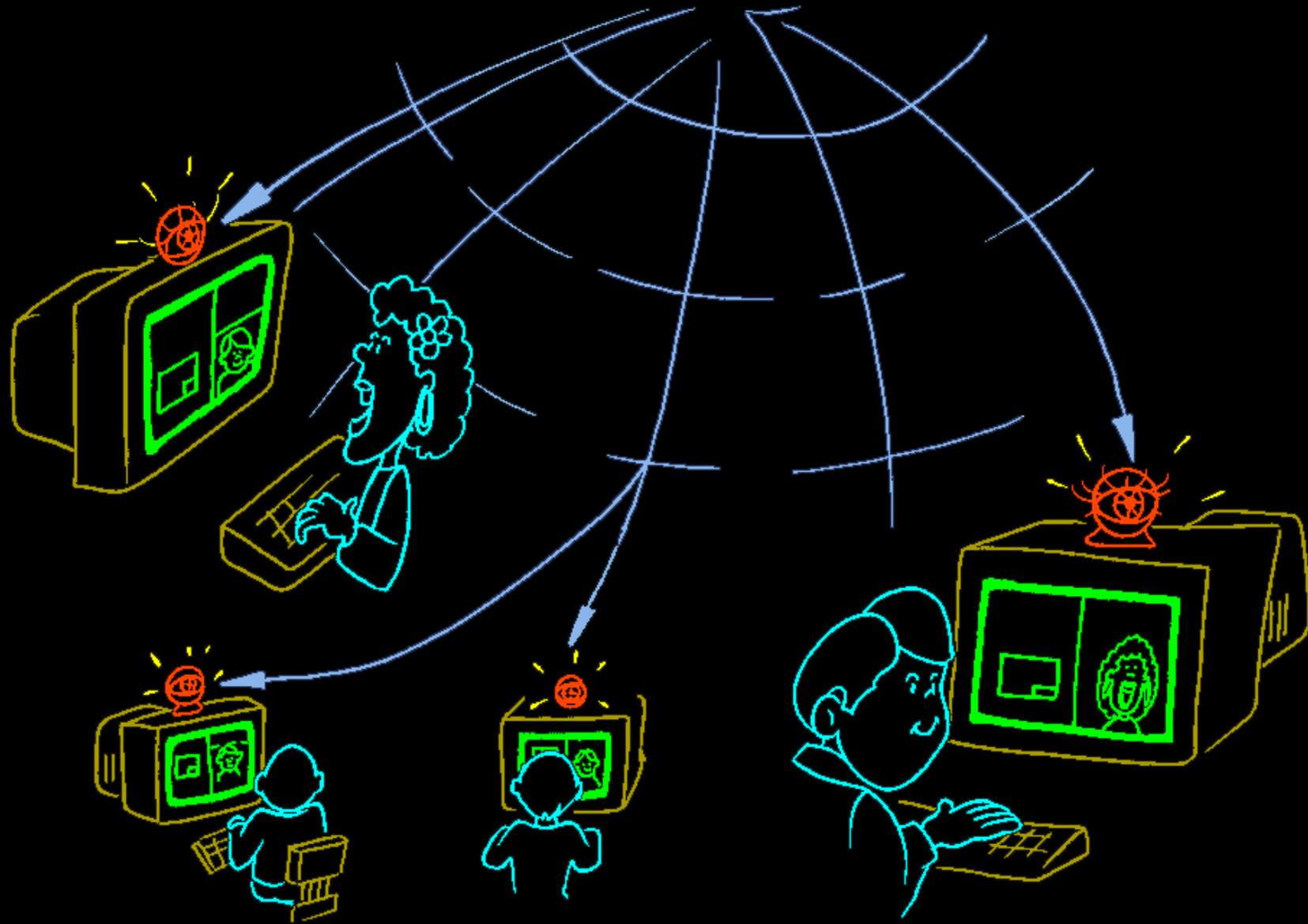
# Virtual Project Team



# Hyperlinked Organization



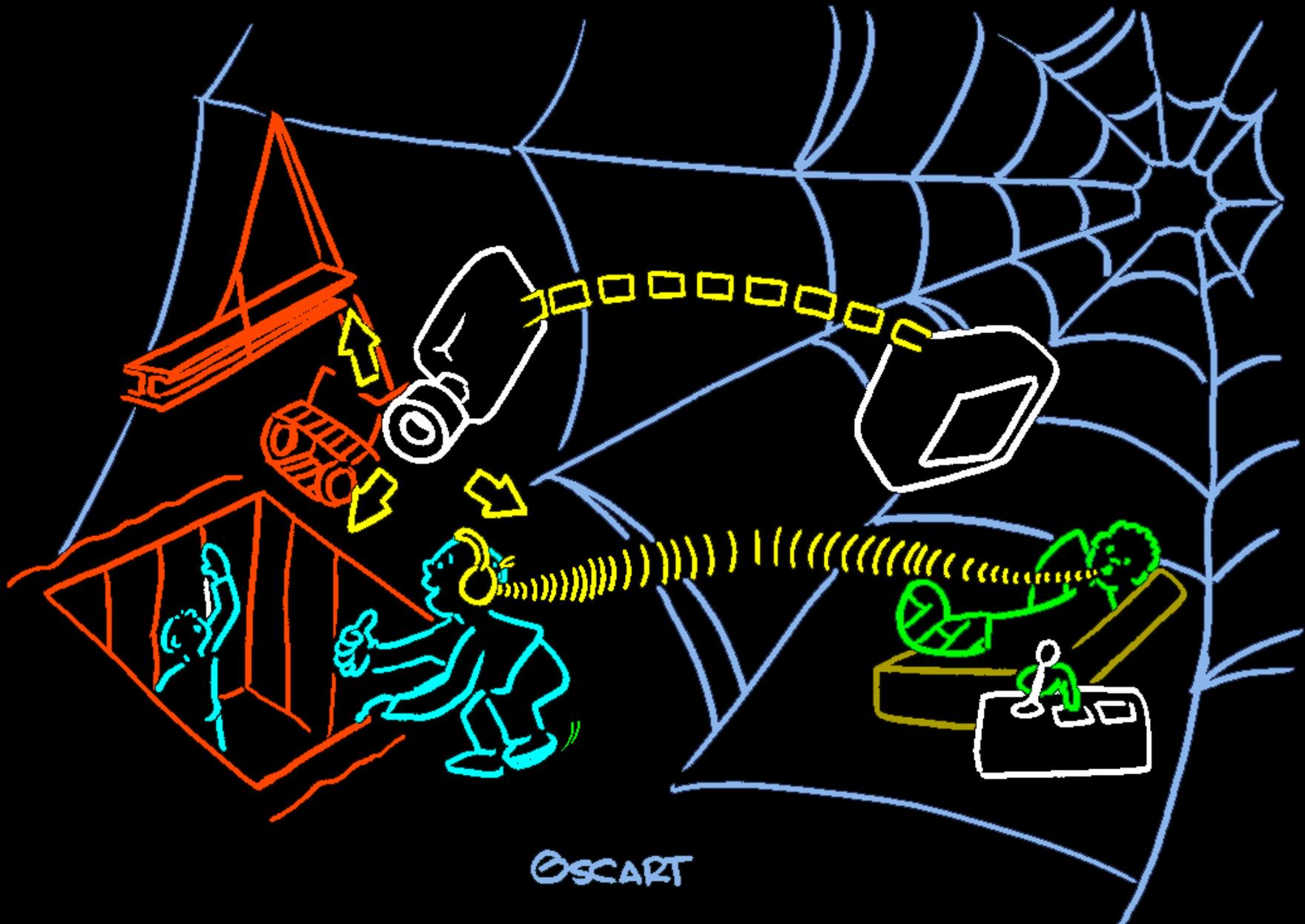
# Desktop Video Conferencing



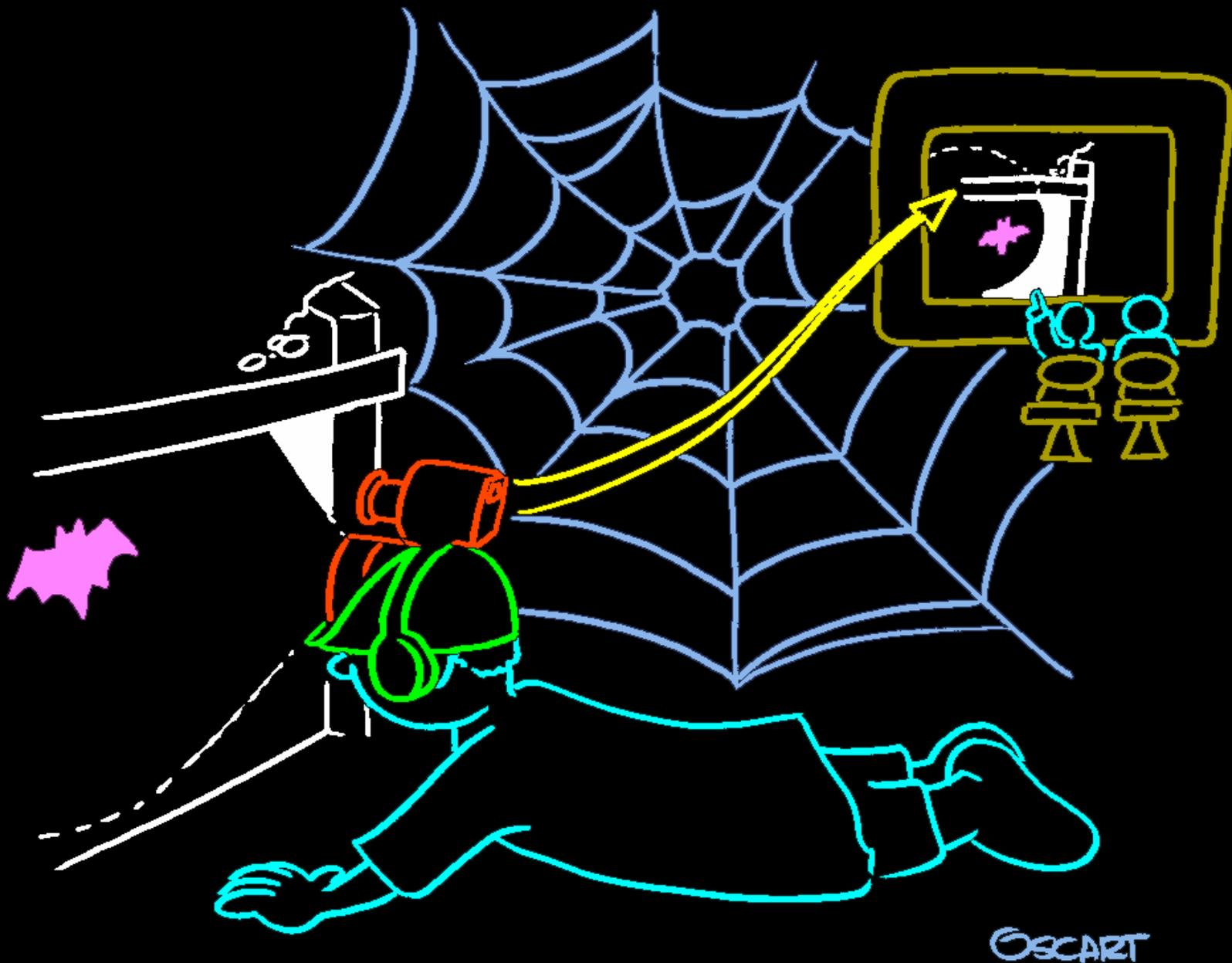
# Real-Time Collaboration



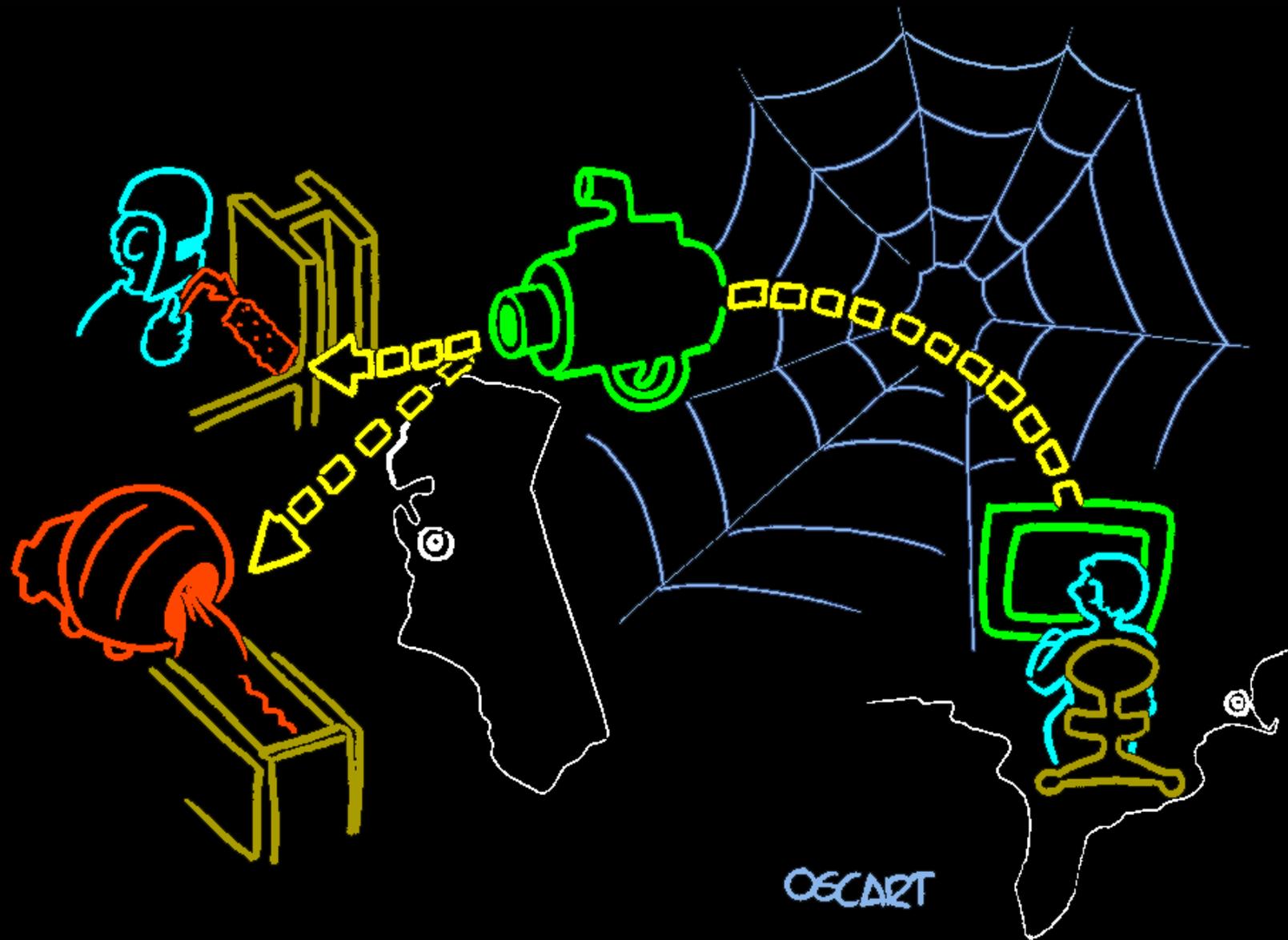
# Site Cam



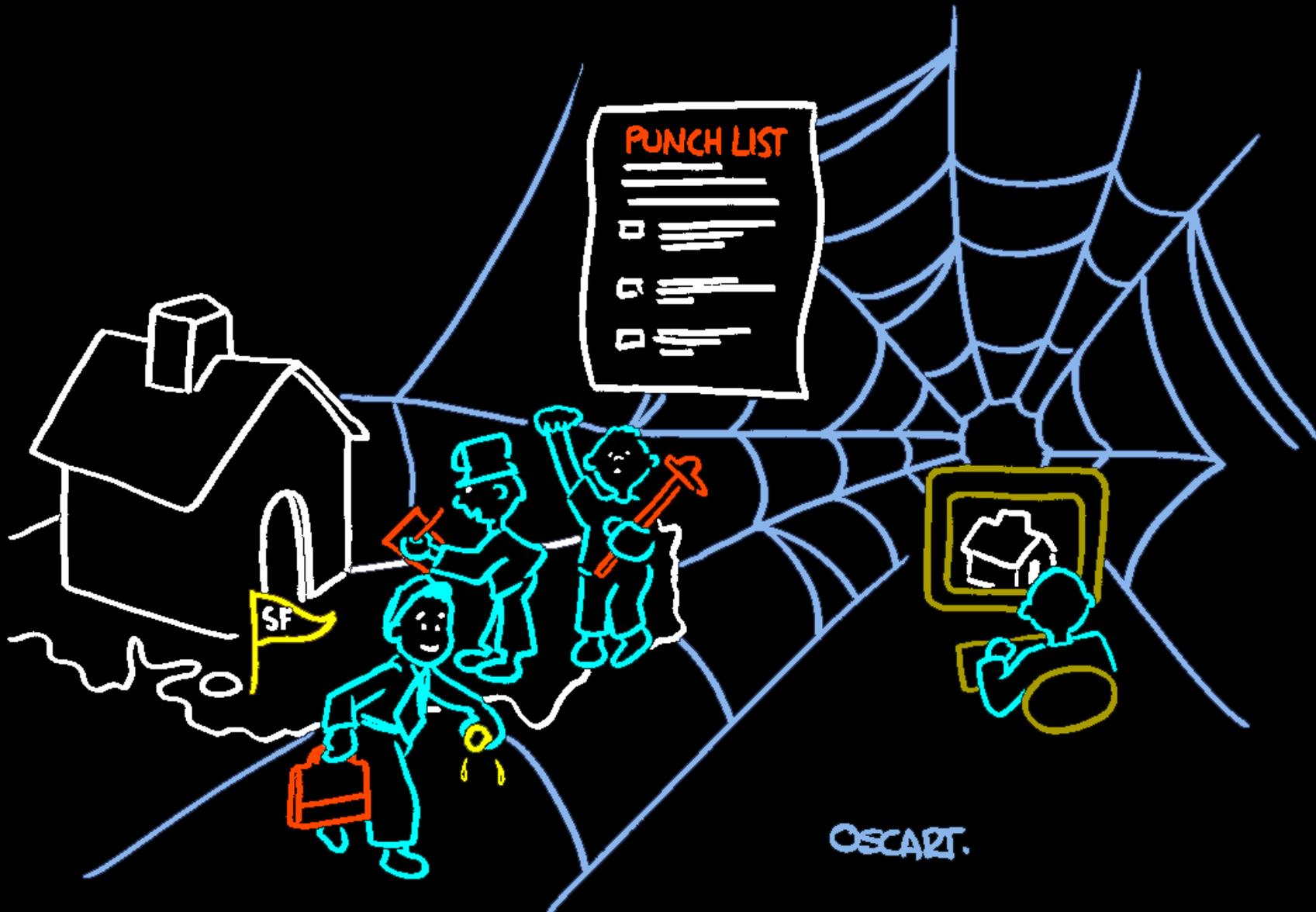
# Hard Hat Camera



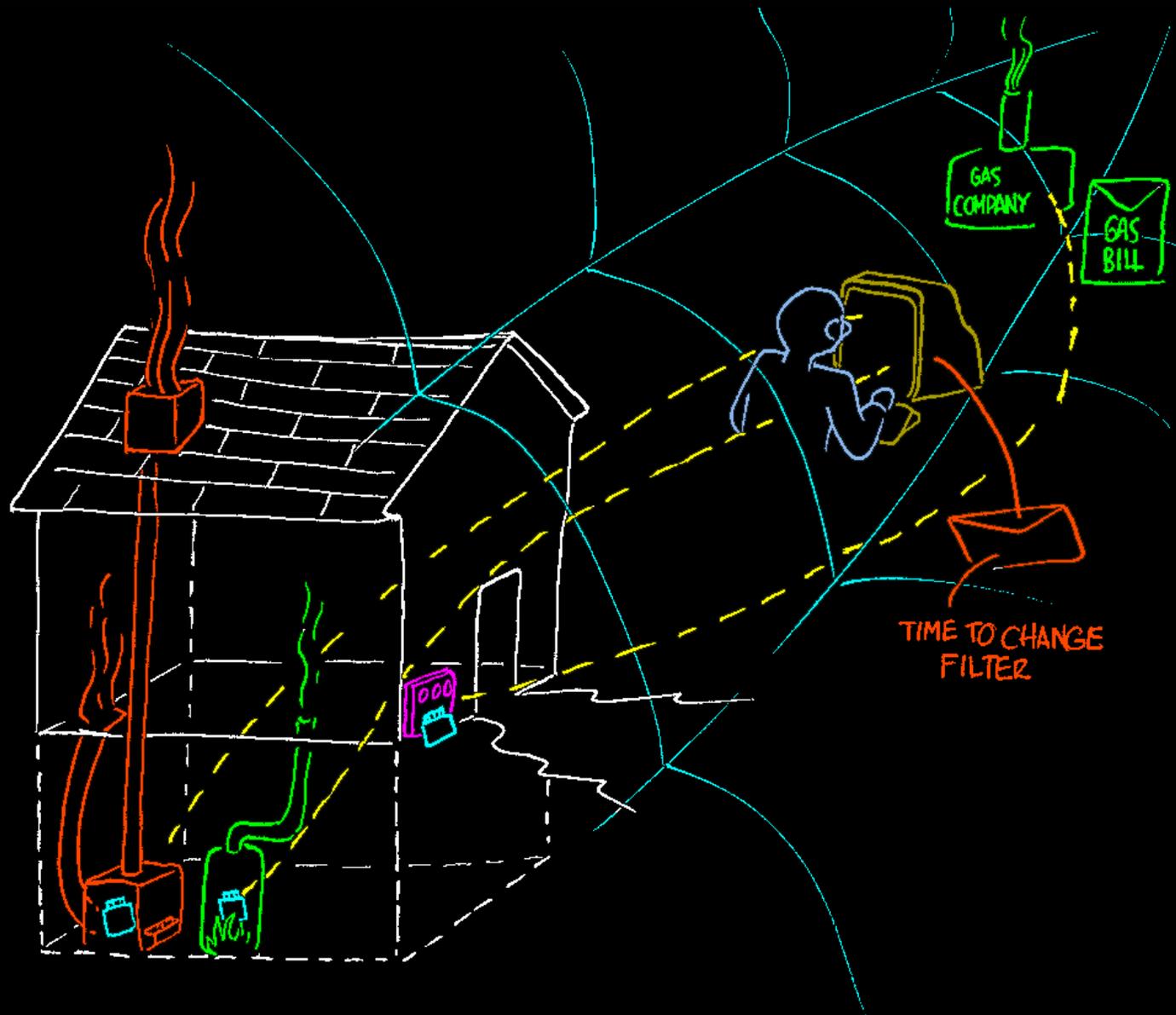
# Remote Field Testing



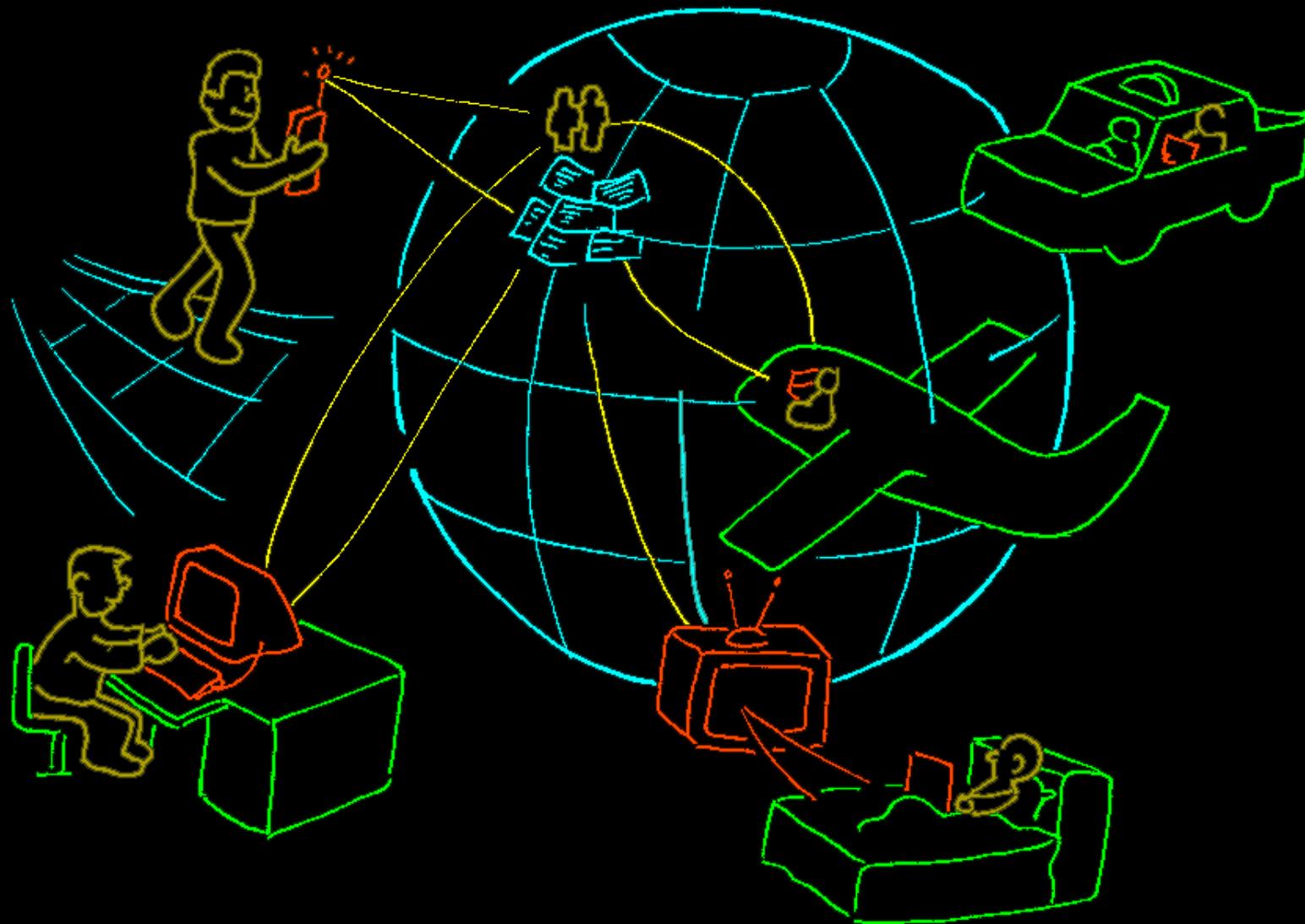
# Punch List



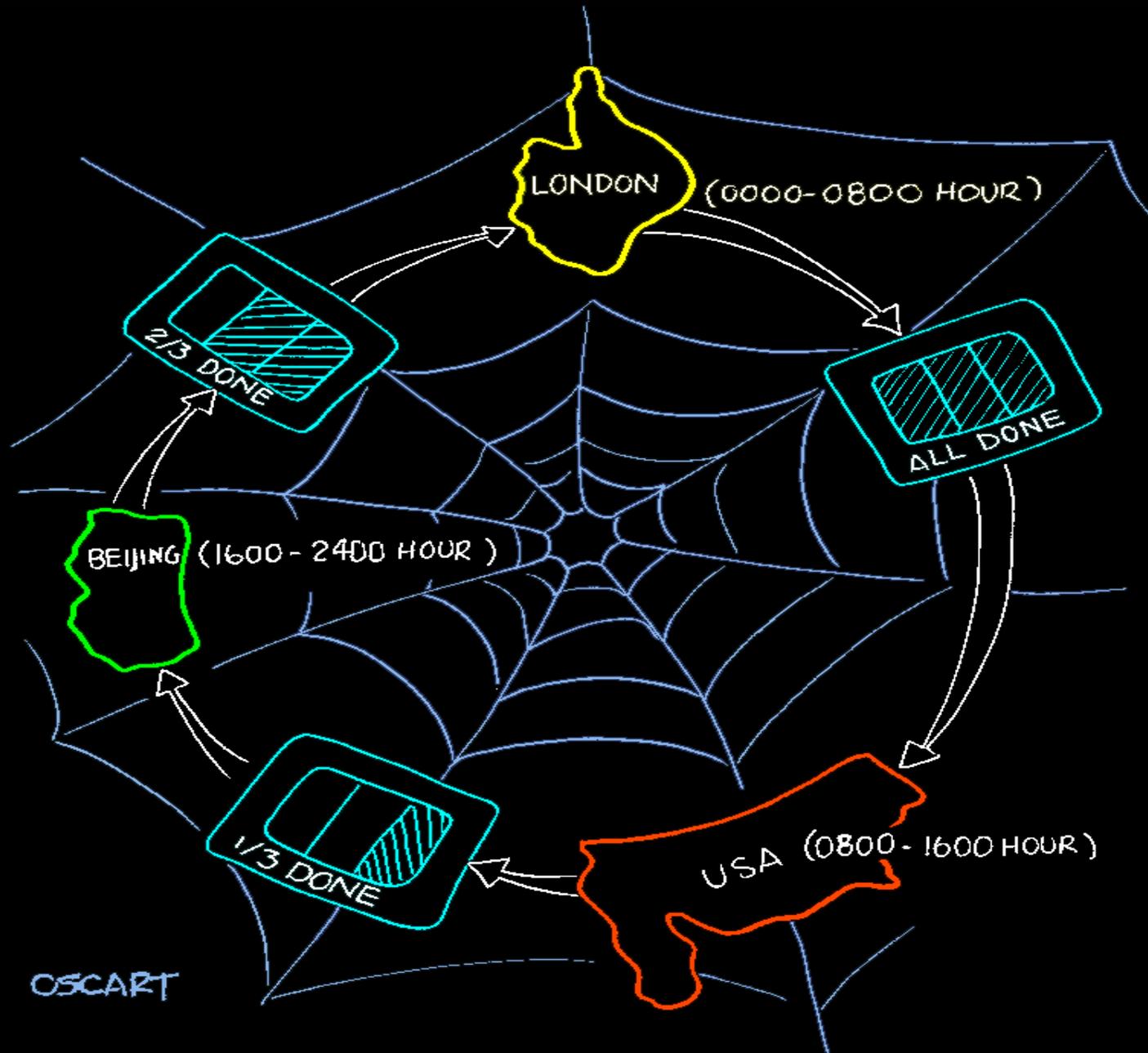
# Remote Reading & Sensing



# Universal Connectivity



# 24 Hour Operation

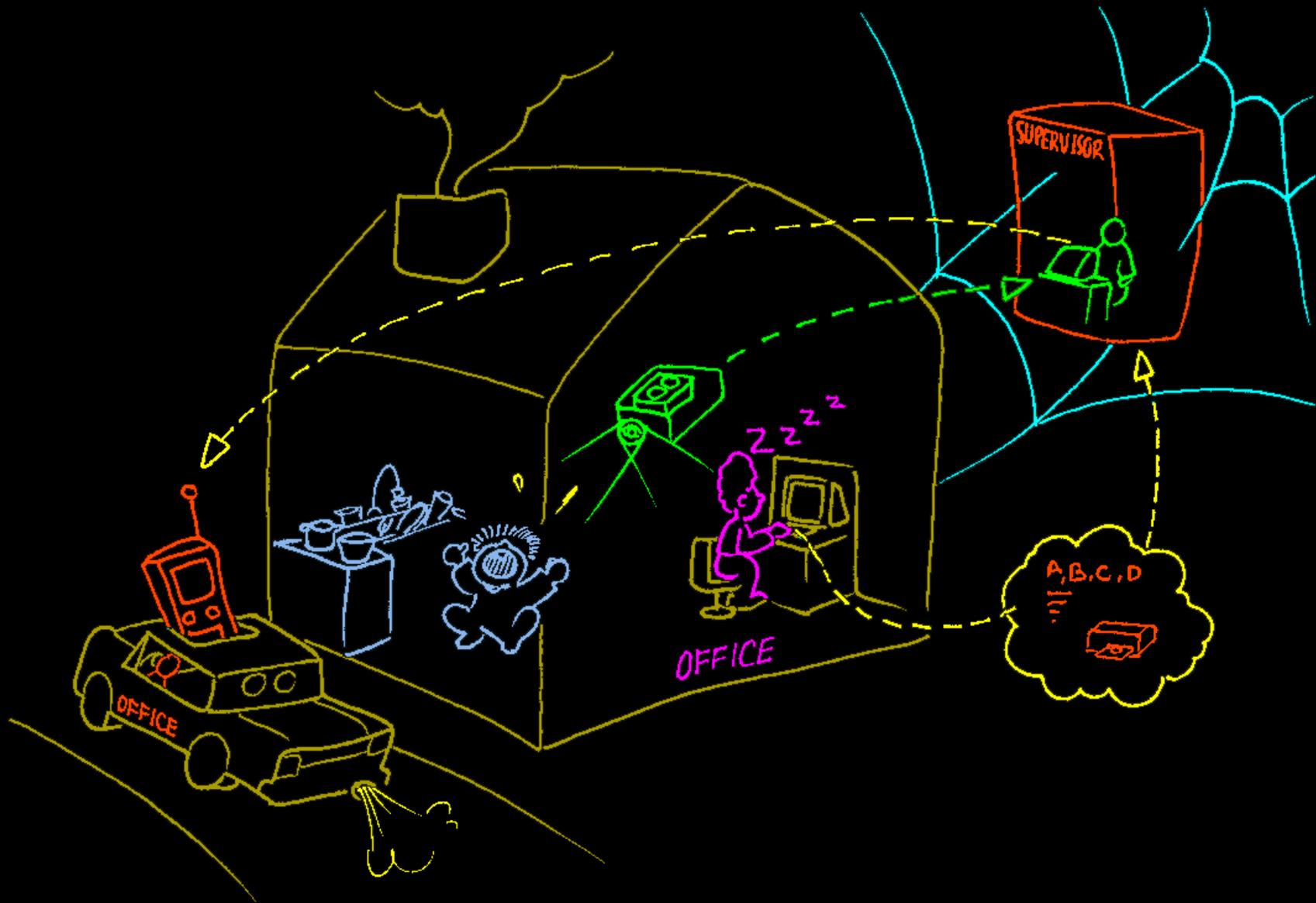


# Shift Turnover Video Diary

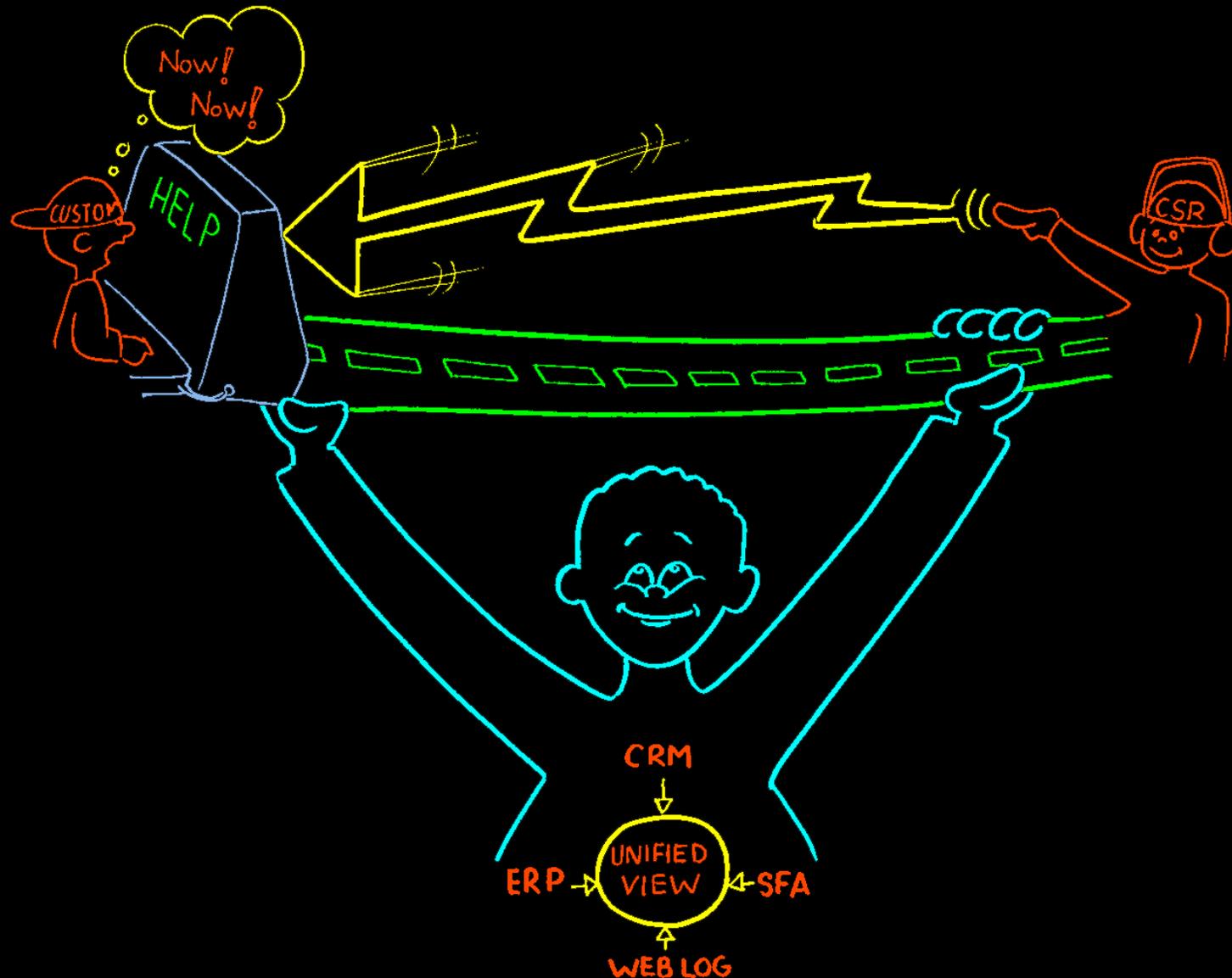


OSCART

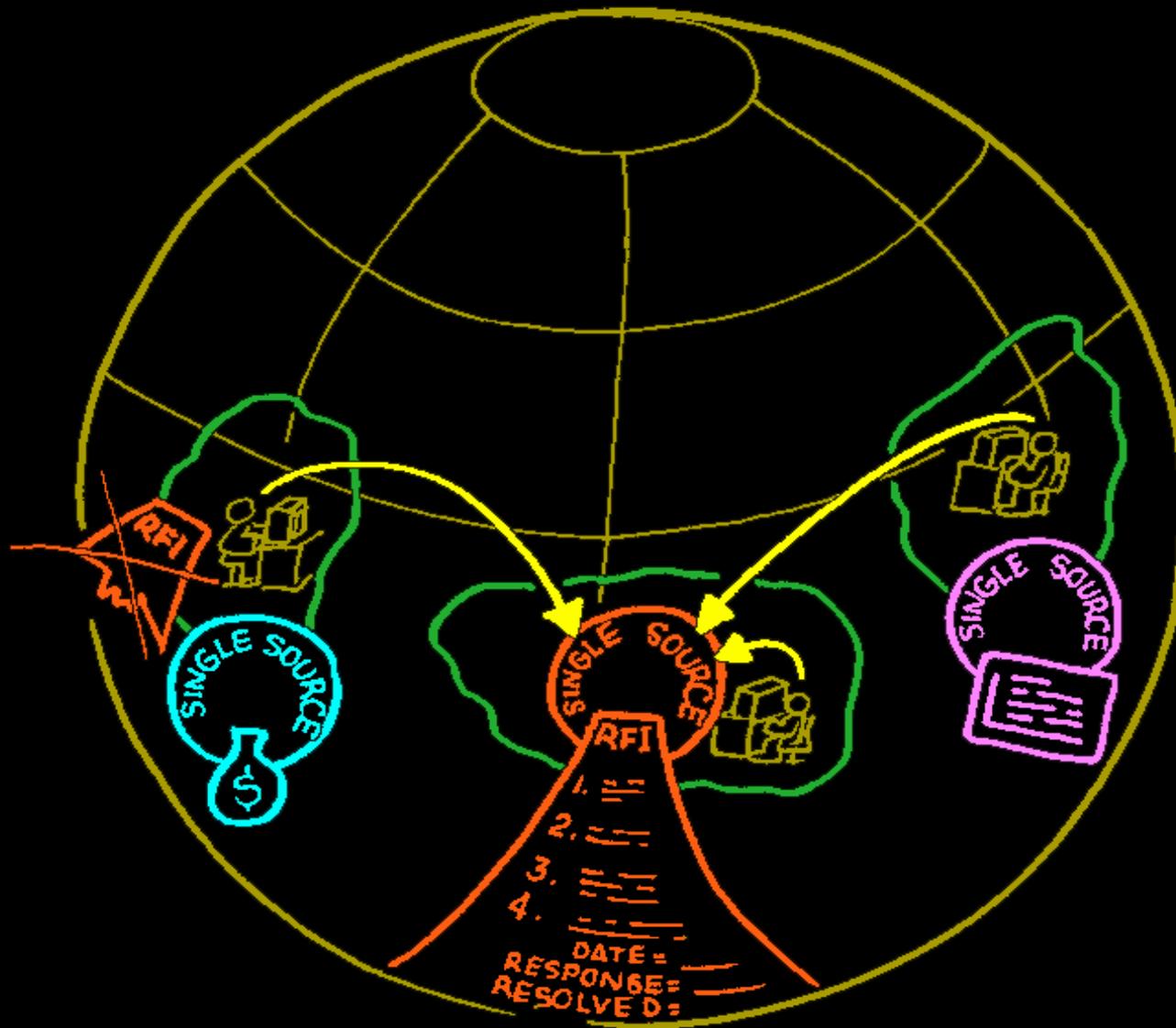
# Telecommuting



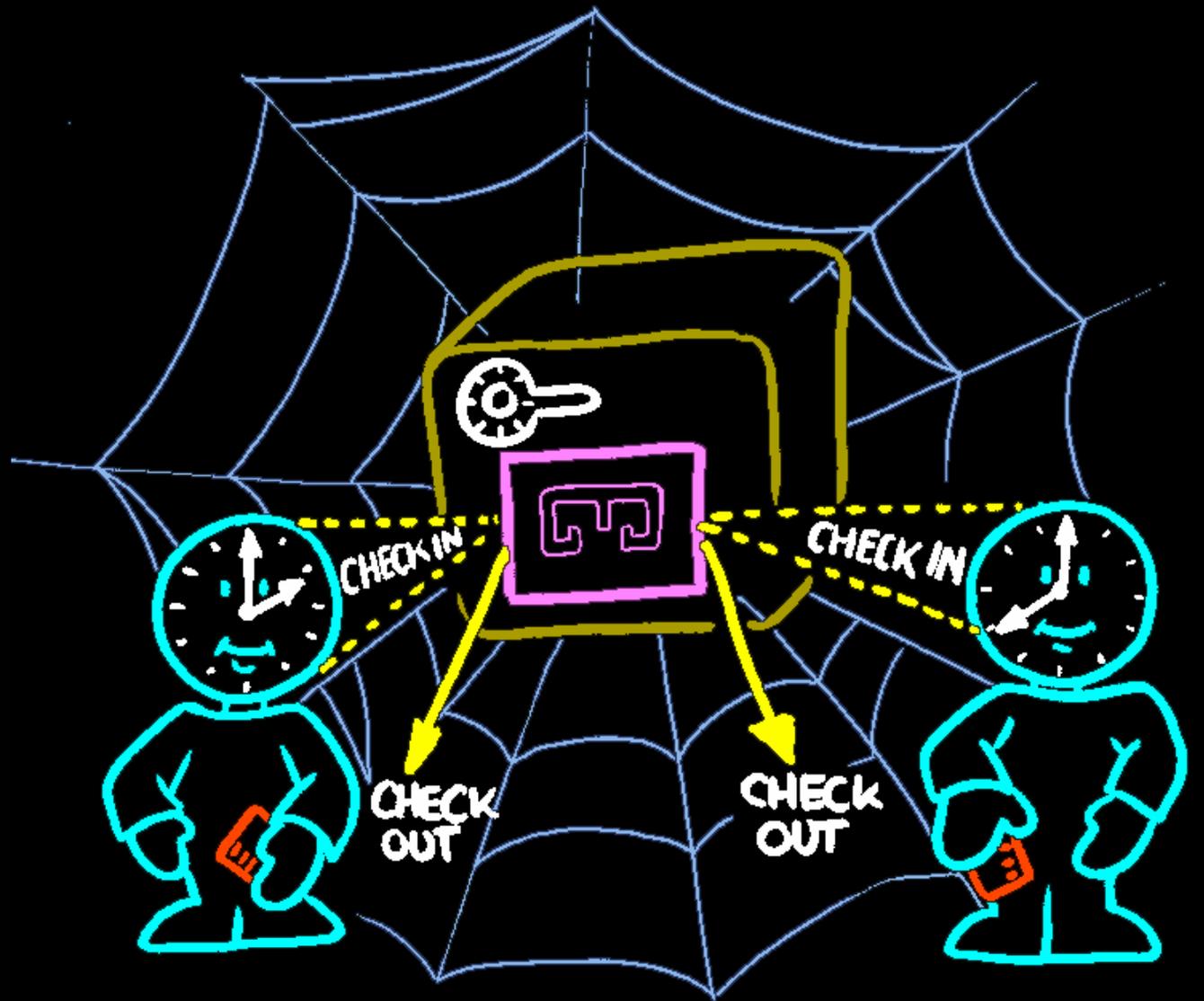
# Be a Real-Time Enterprise



# Single Source

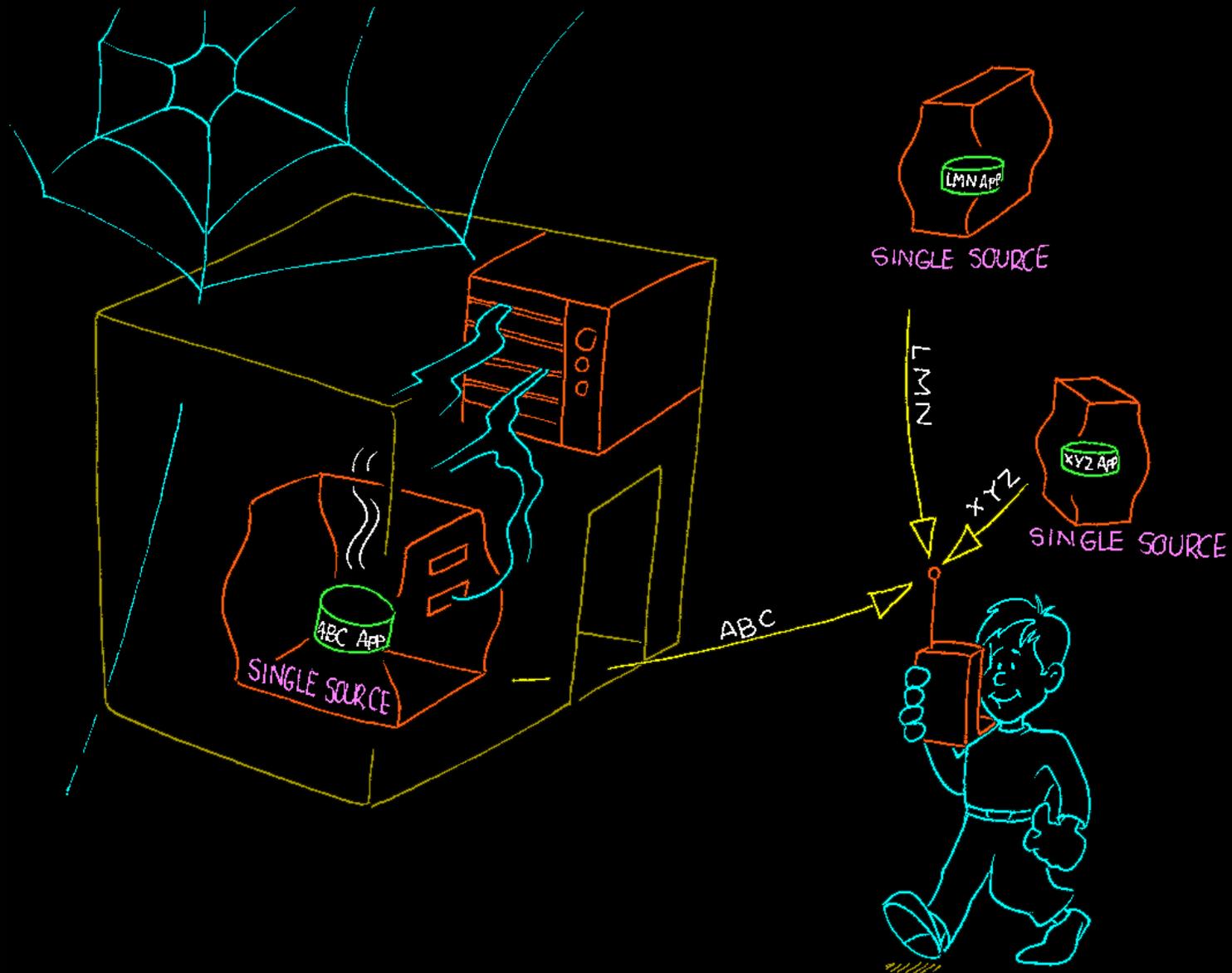


# Check In & Check Out

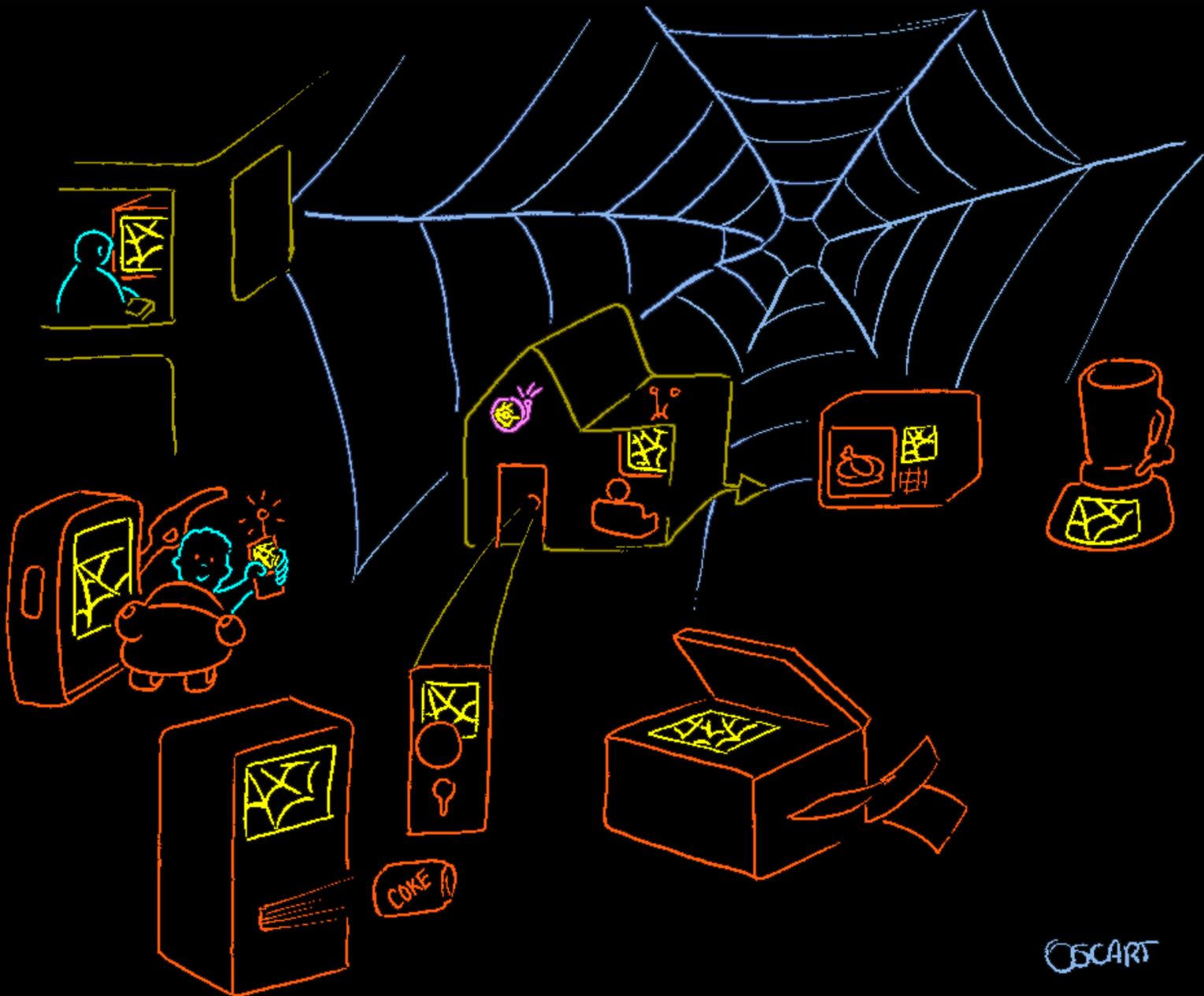


ESCART

# Re-Centralization



# Distributed Information Devices



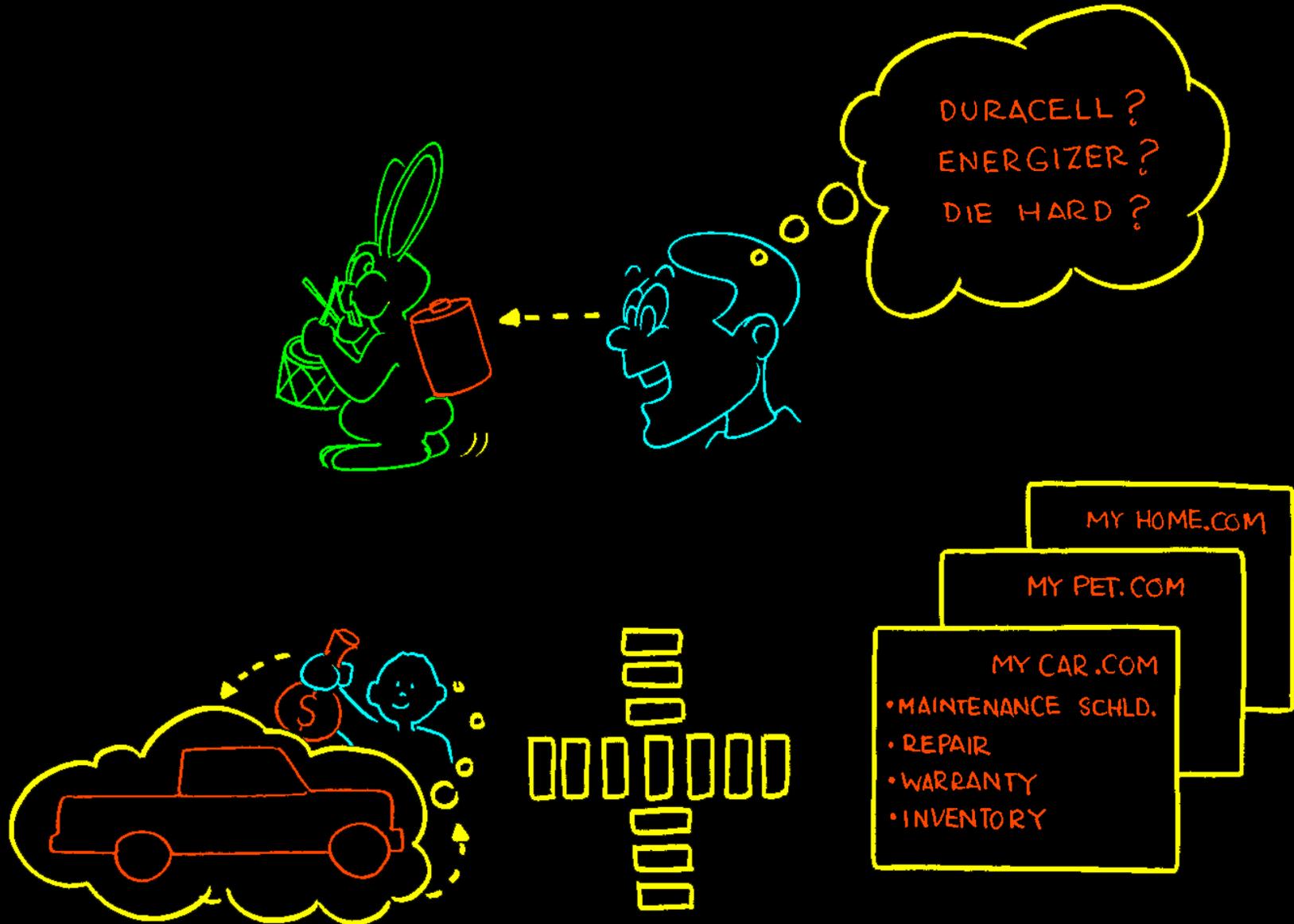
# Broadband Applications

- **Movie/Video-on-demand and sharing**
- **Video e-mail**
- **Video phone**
- **Video conferencing**
- **Real-time e-learning**
- **Interactive games**
- **Music online**
- **Instant messaging**
- **Telecommuting**
- **Remote business activities**
- **Application sharing (users take turns)**
- **Whiteboarding (drawing simultaneously)**
- **Remote assistance (control of other's computer)**
- **Real-time translation of speech**
- **Tele-operation (e.g. hazard monitoring)**
- **Augmented reality**

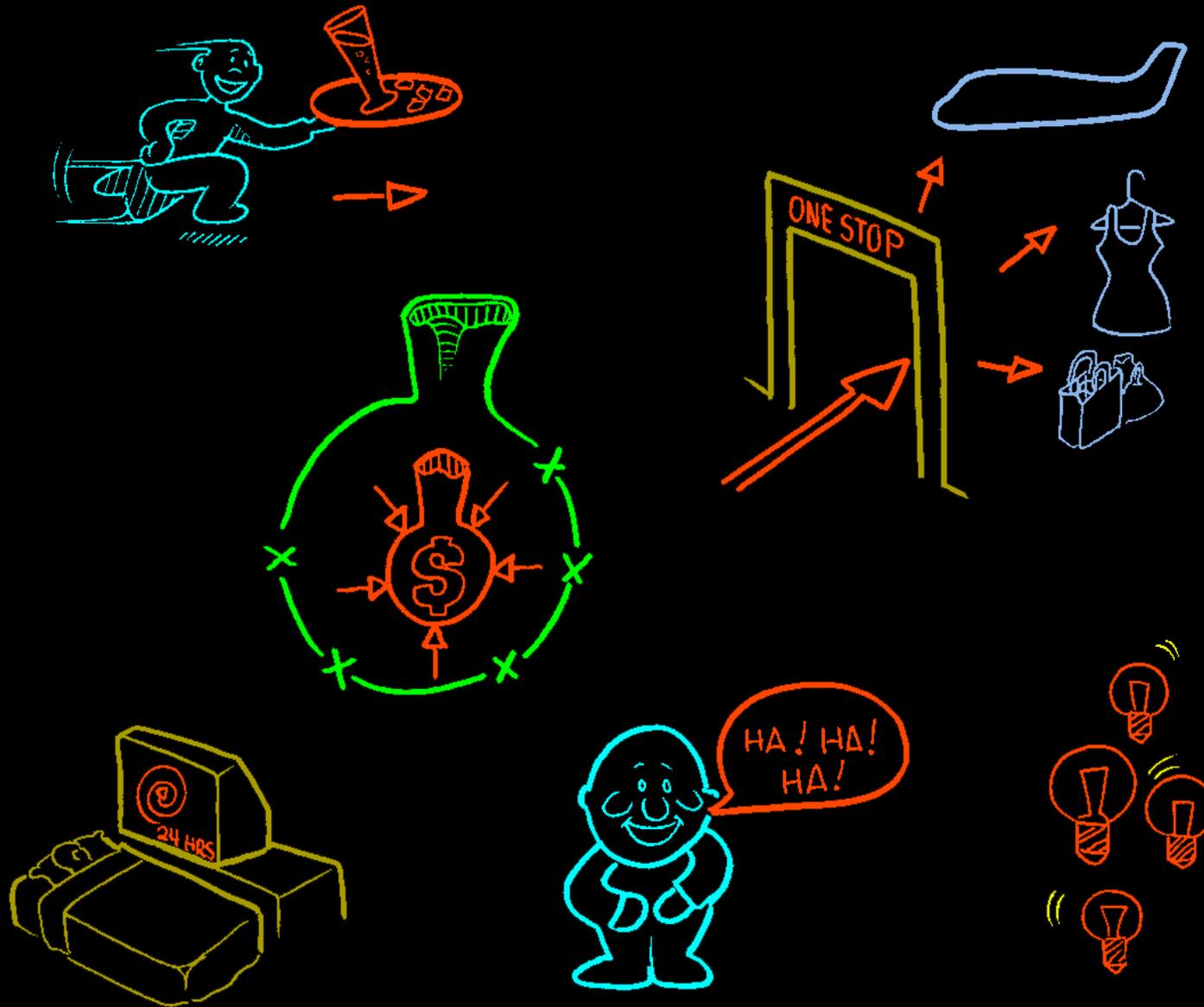
# Future Home Bandwidth

- **HDTV** (720x1080; 16:9): **15-38 Mbps**
- **SDTV: 5-10**
- **Internet Access: 5**
- **Games: 2**
- **Voice phone: .064-.256**
- **Security: .5**
- **Total: 30-50 Mbps**
  - 75% available // 10% have BB
  - TechNet: 100 Mbps/100m homes

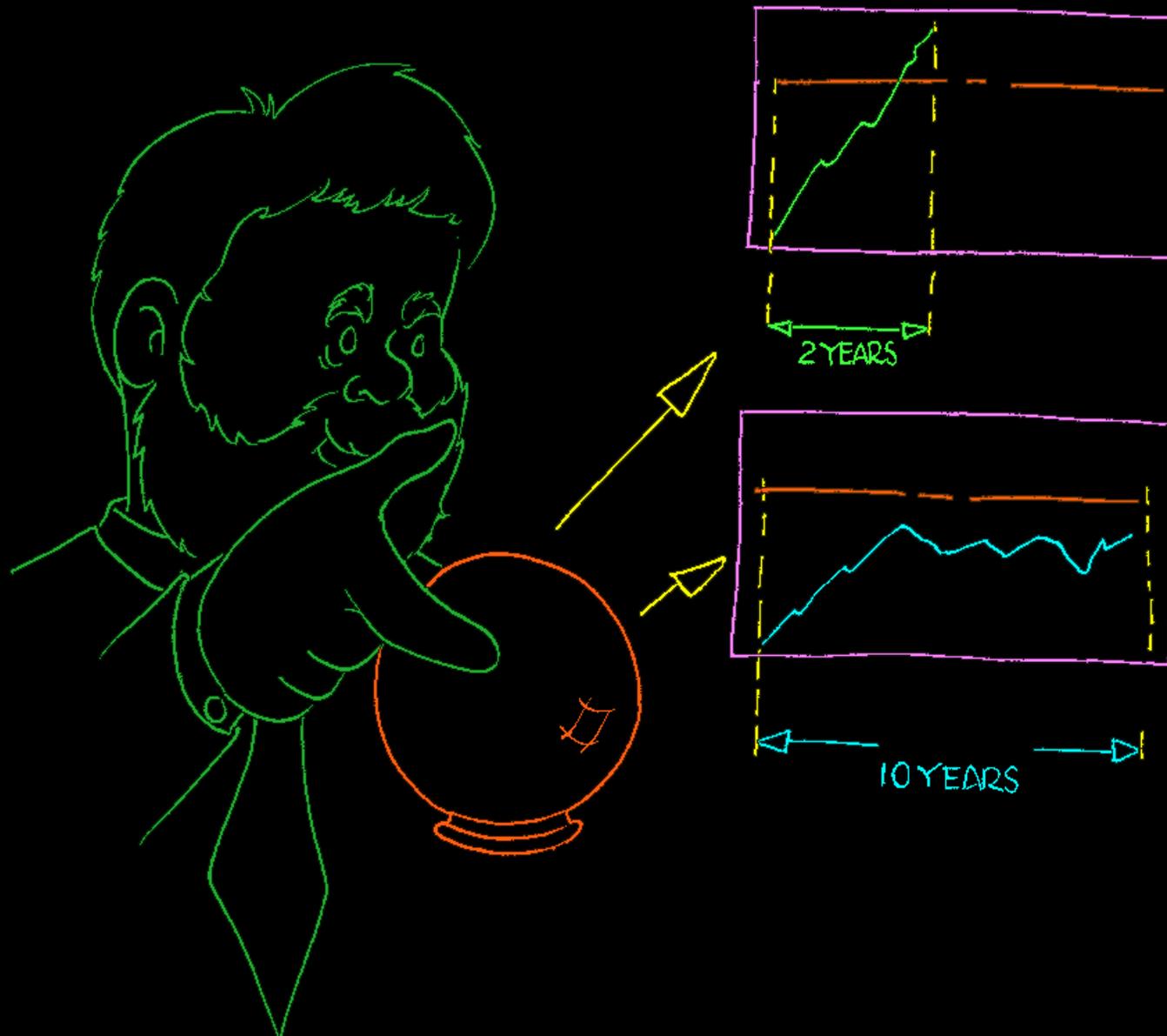
# Differentiation



# Competitive Advantage



# Technology Revolution



# Thank You



OSCAR.T.