

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

Kaiman Lee, Ph.D., R.A.

President

VisionQuest Today

kaiman_lee@yahoo.com

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)

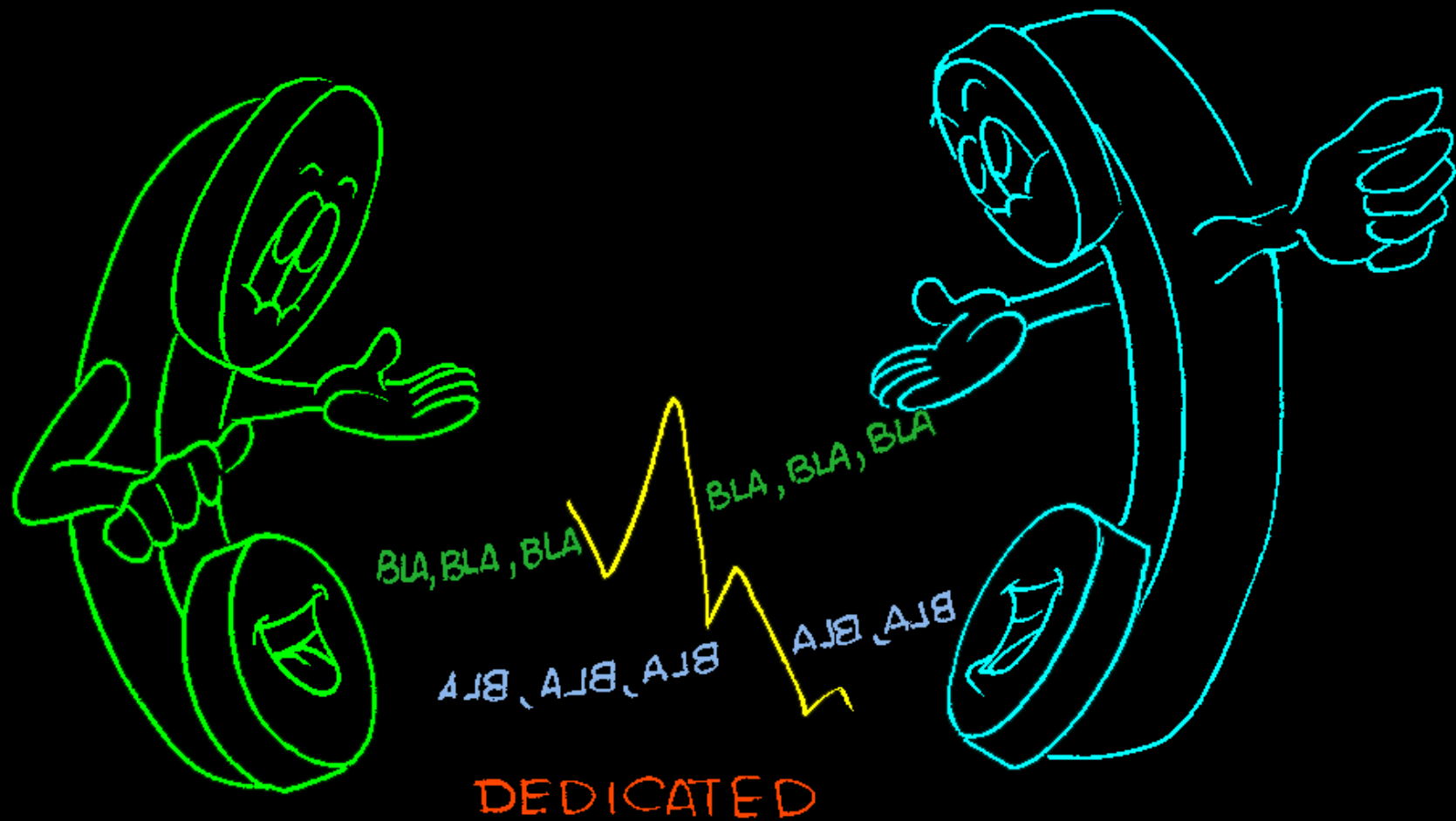
Digital Signal Processing (DSP)

- **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**

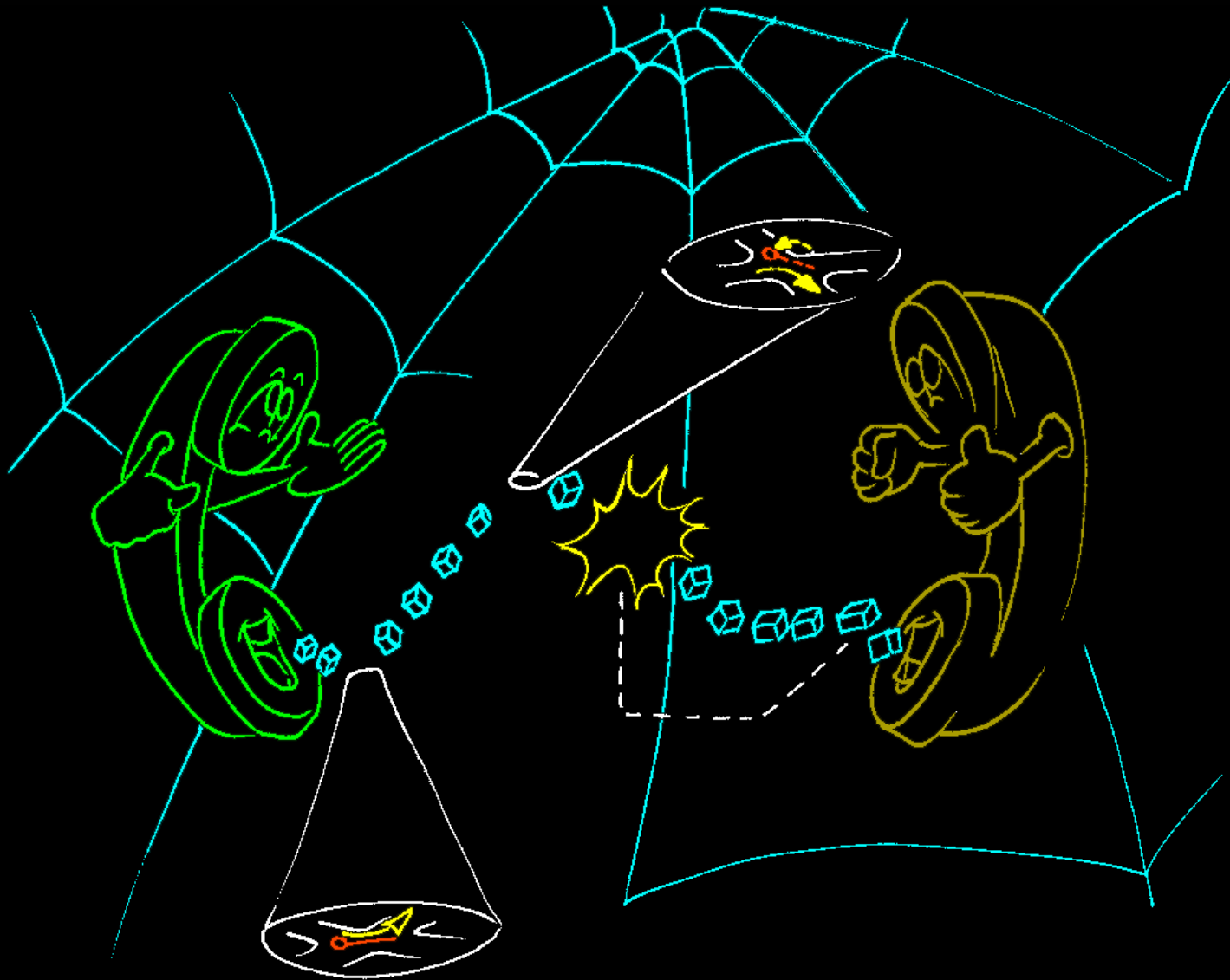
LEC/ILEC/CLEC .. BOC/RBOC

- **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

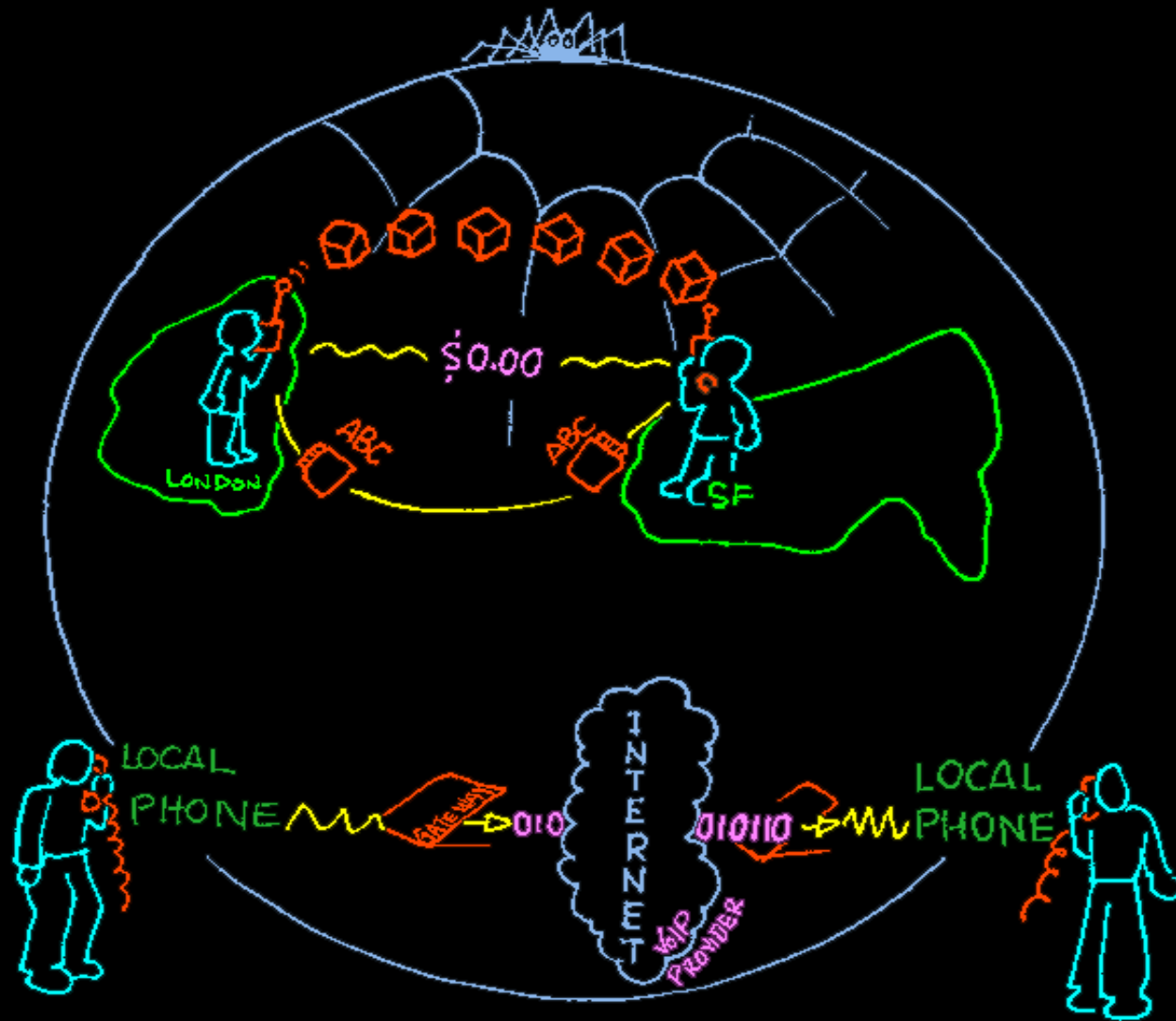
Circuit Switching



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**

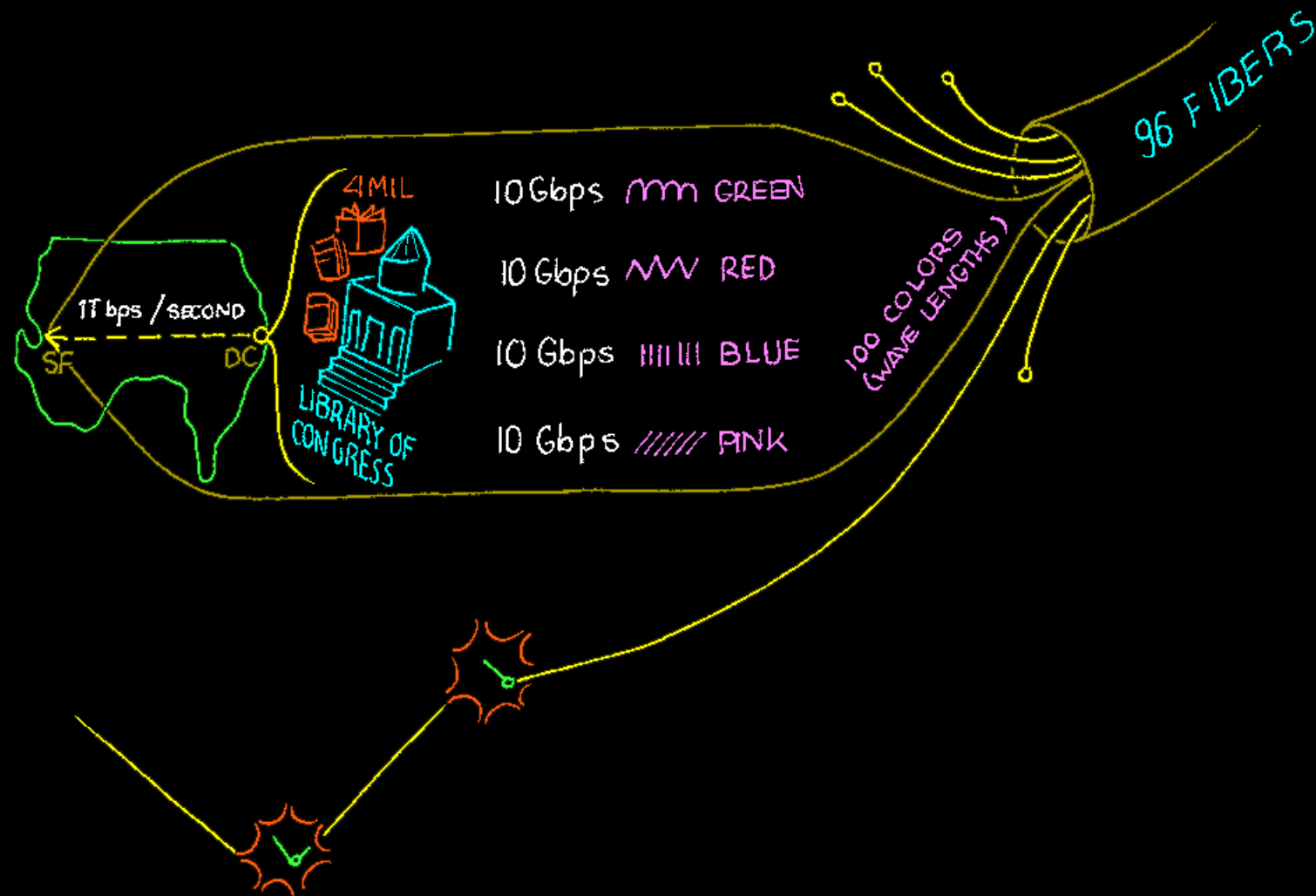
Ethernet

- **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

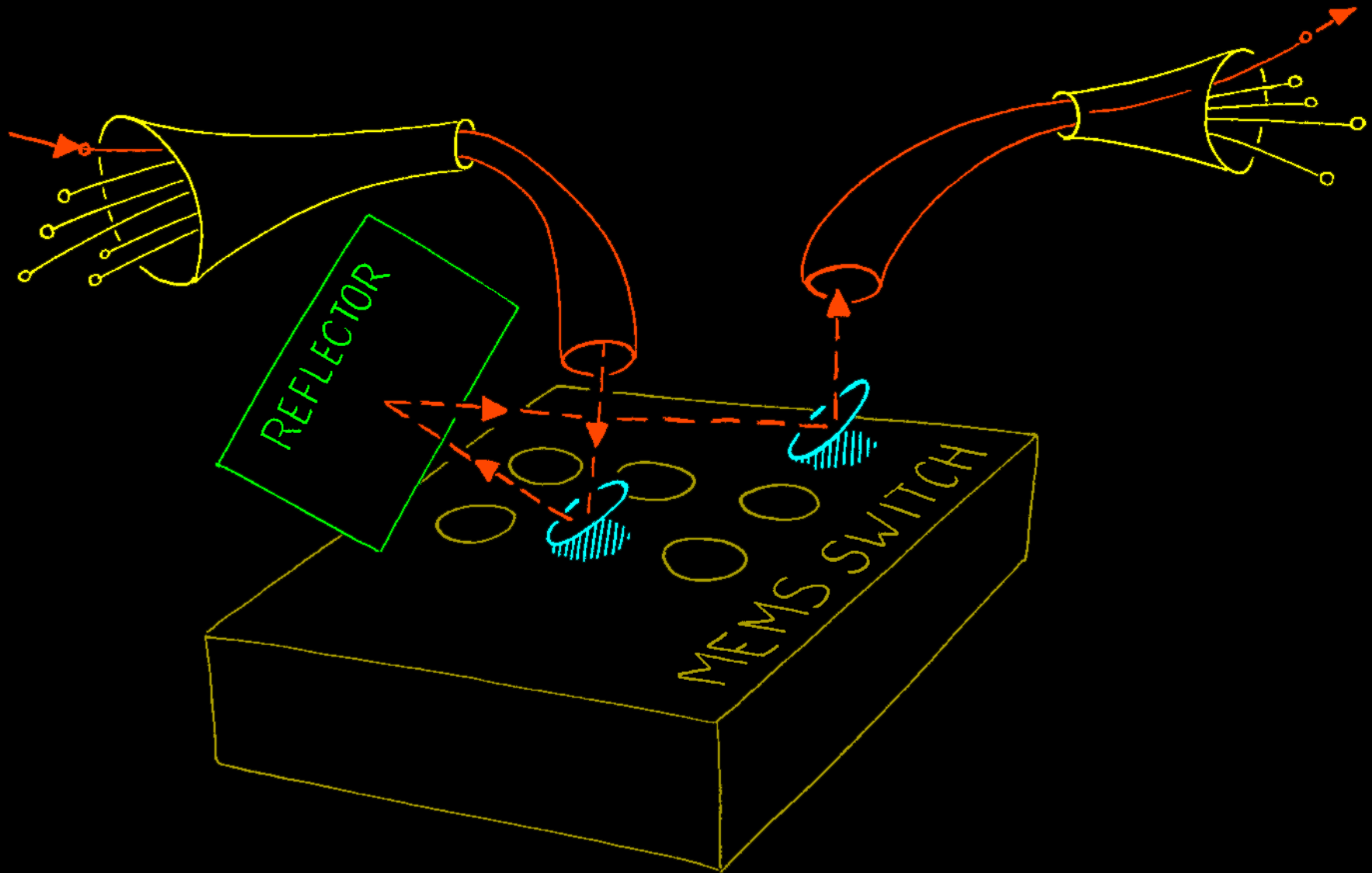
Optical Fiber

- 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)

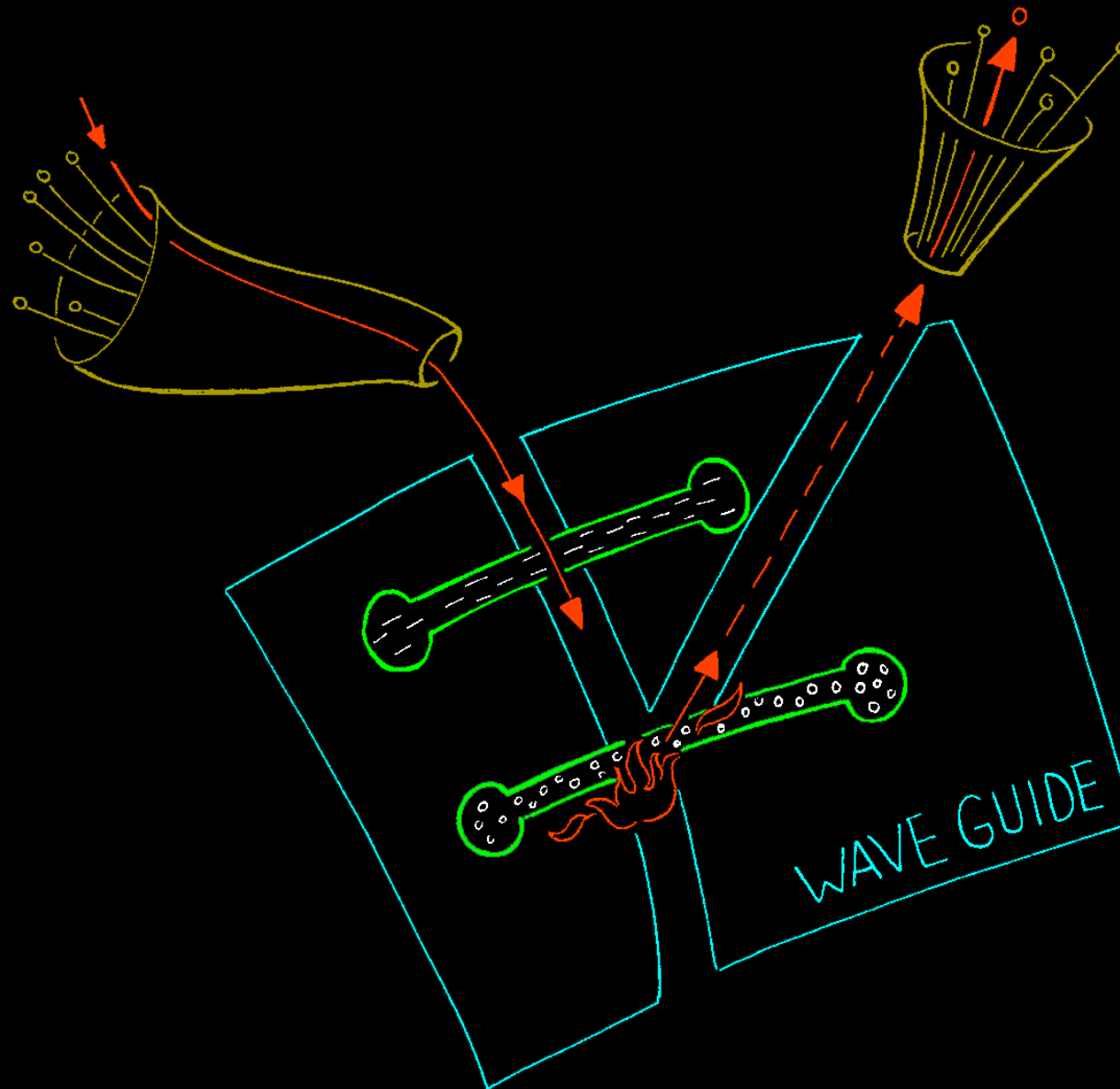
Dense Wavelength Division Multiplexing (DWDM)



MEMS Optical Switch



Bubble Jet Optical Switches



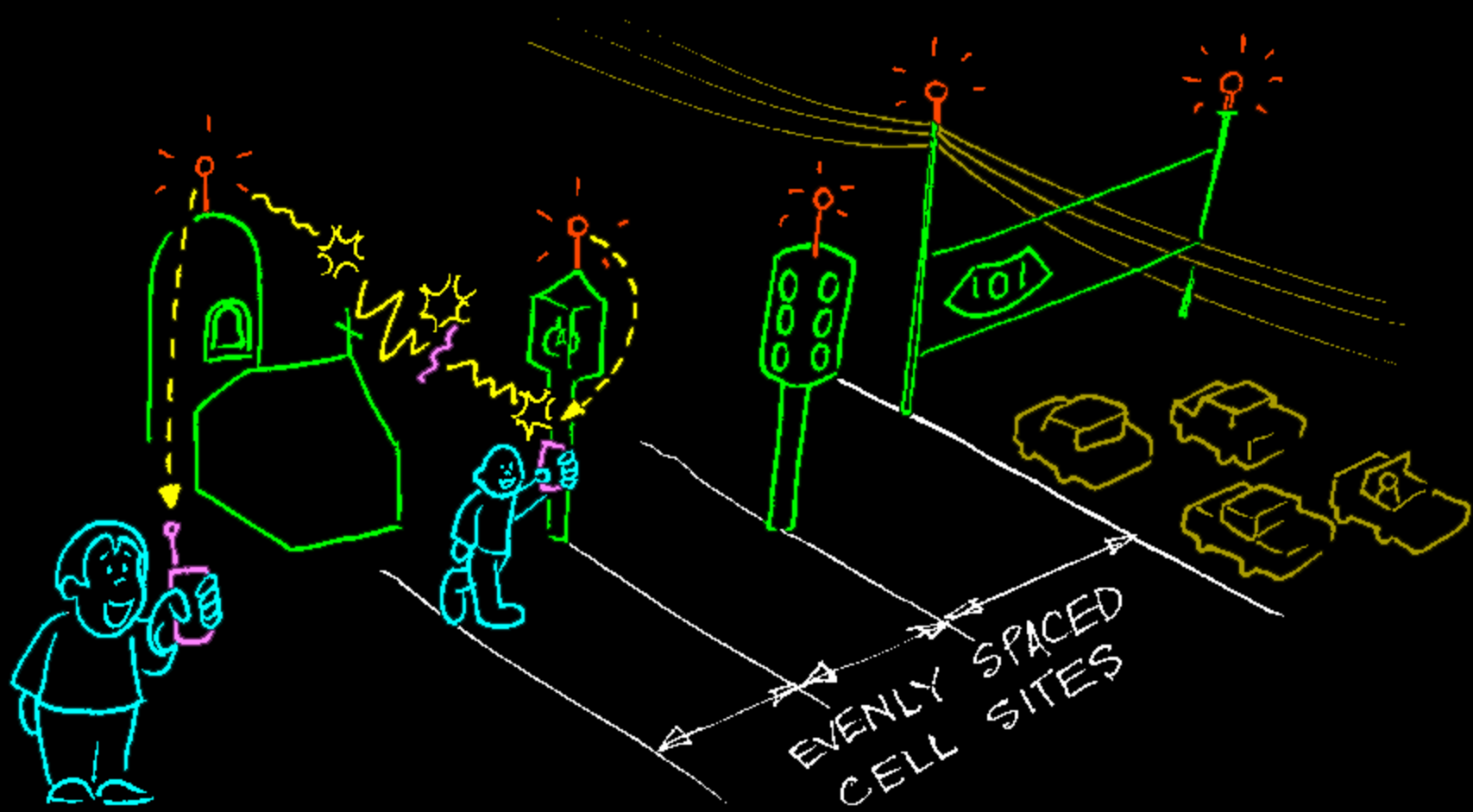
Wireless Speeds

- **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

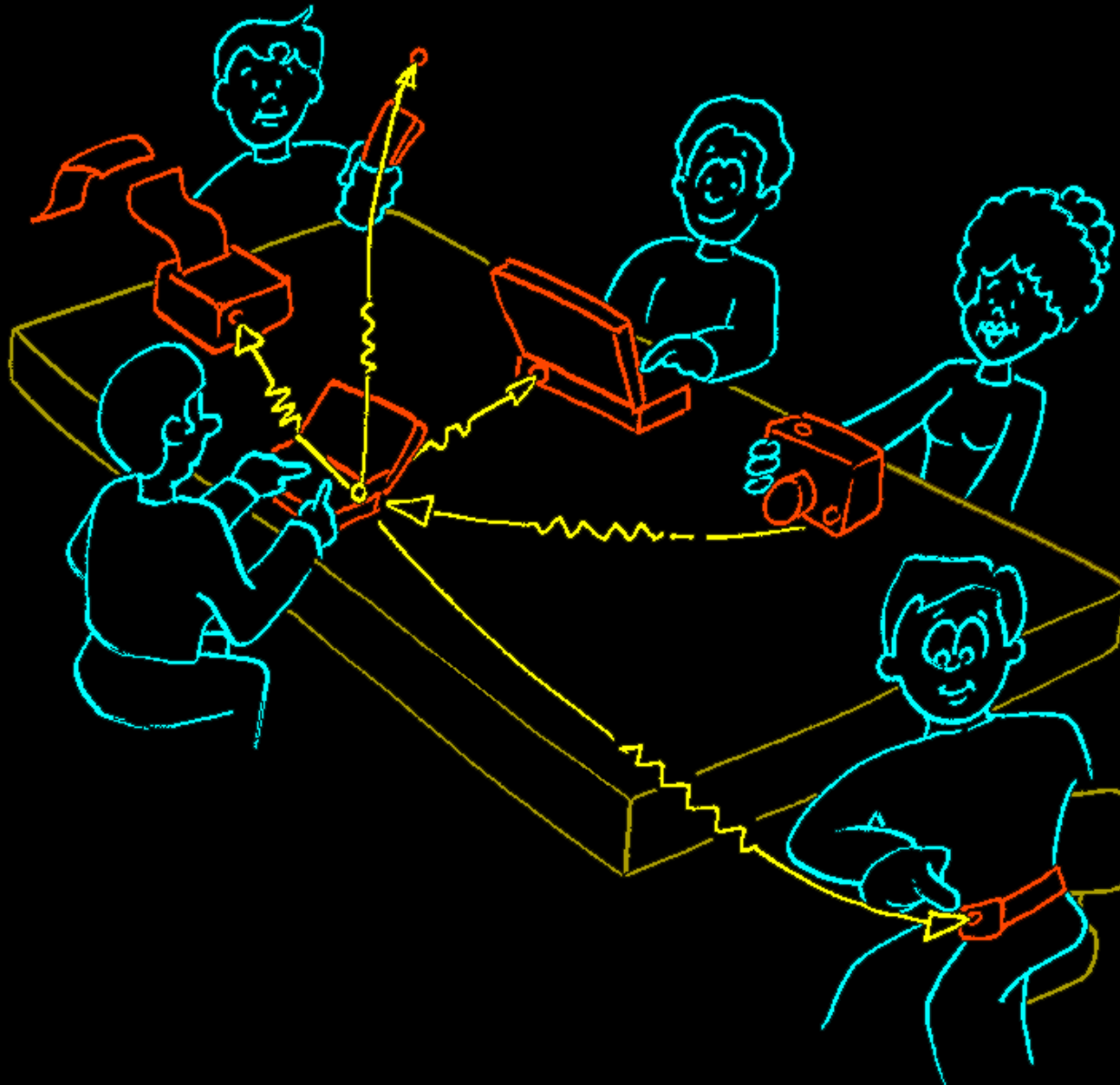
Personal Communication System (PCS)



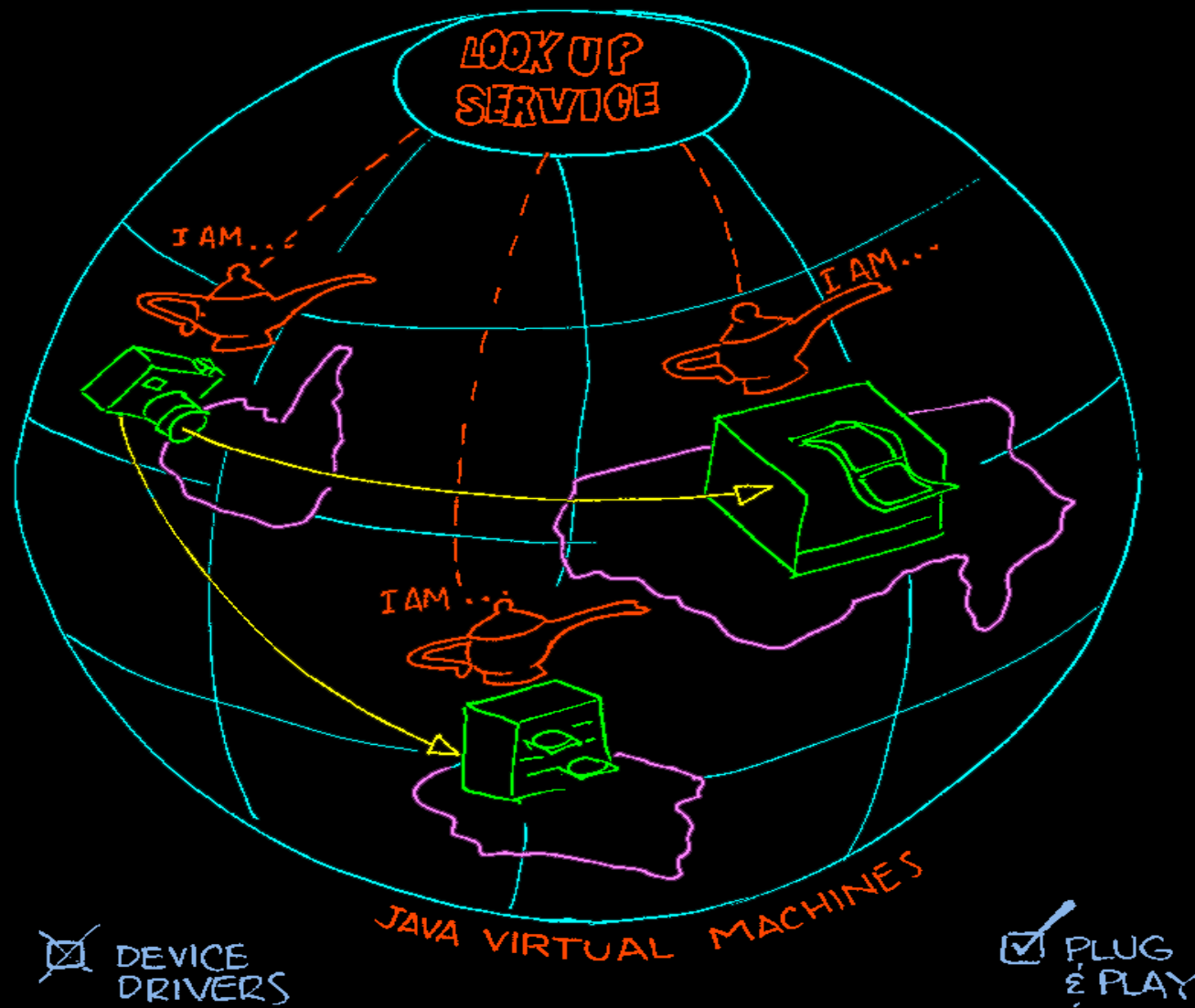
Wi-Fi (Wireless Fidelity)

- **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

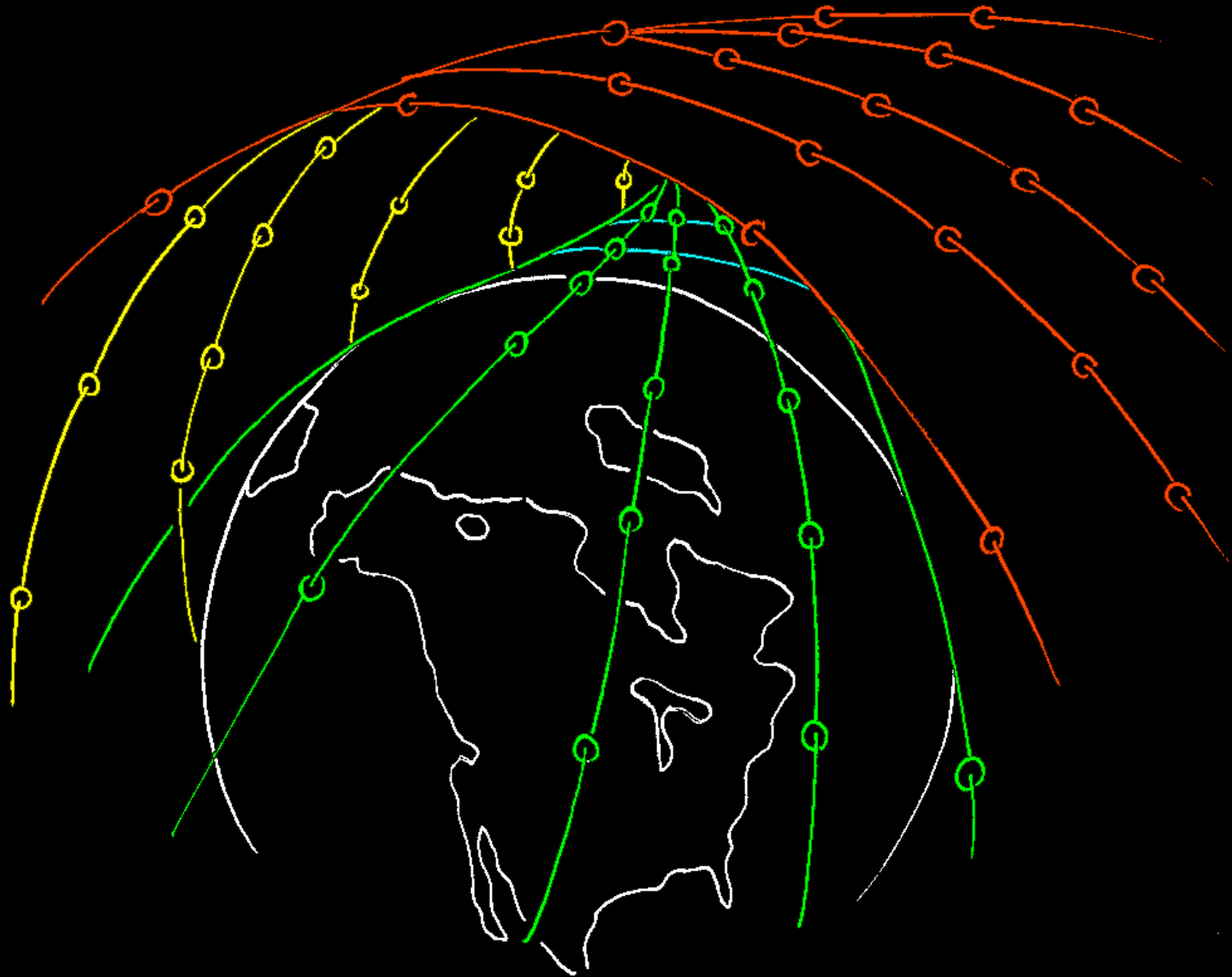
DSL Providers

- 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)

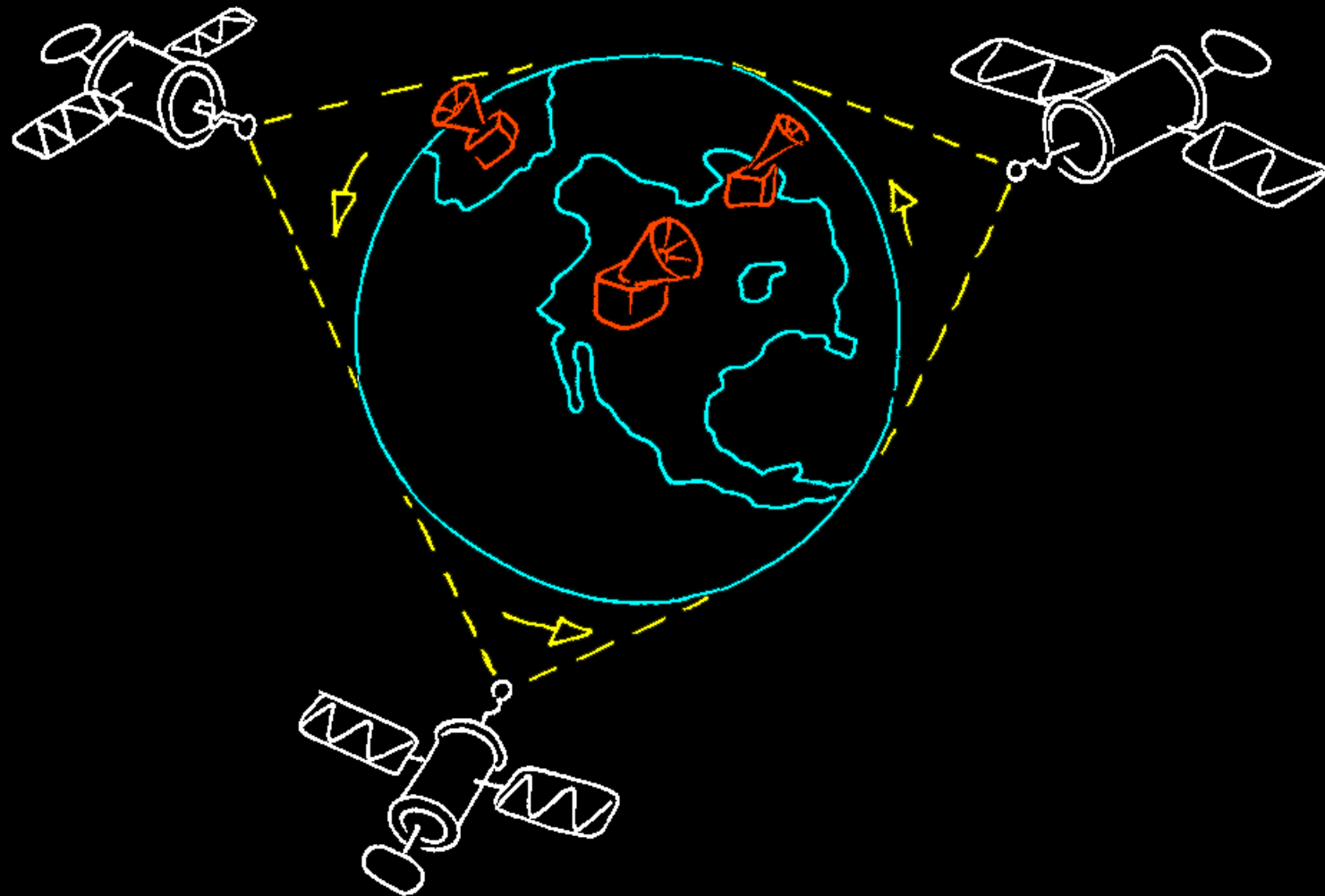
Free-Space Optics (FSO)

- = 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

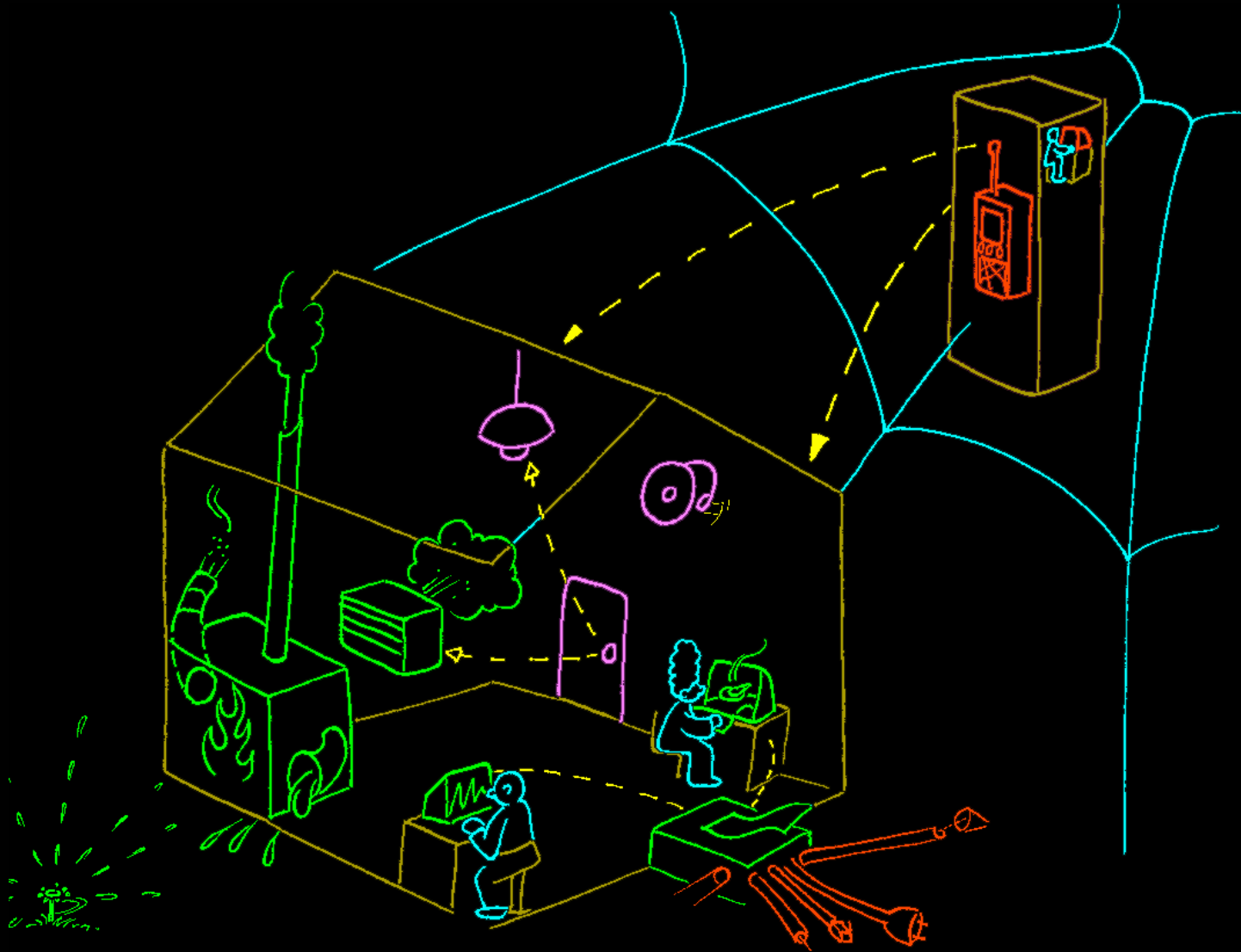
Low Earth Orbit Satellites (LEOs)



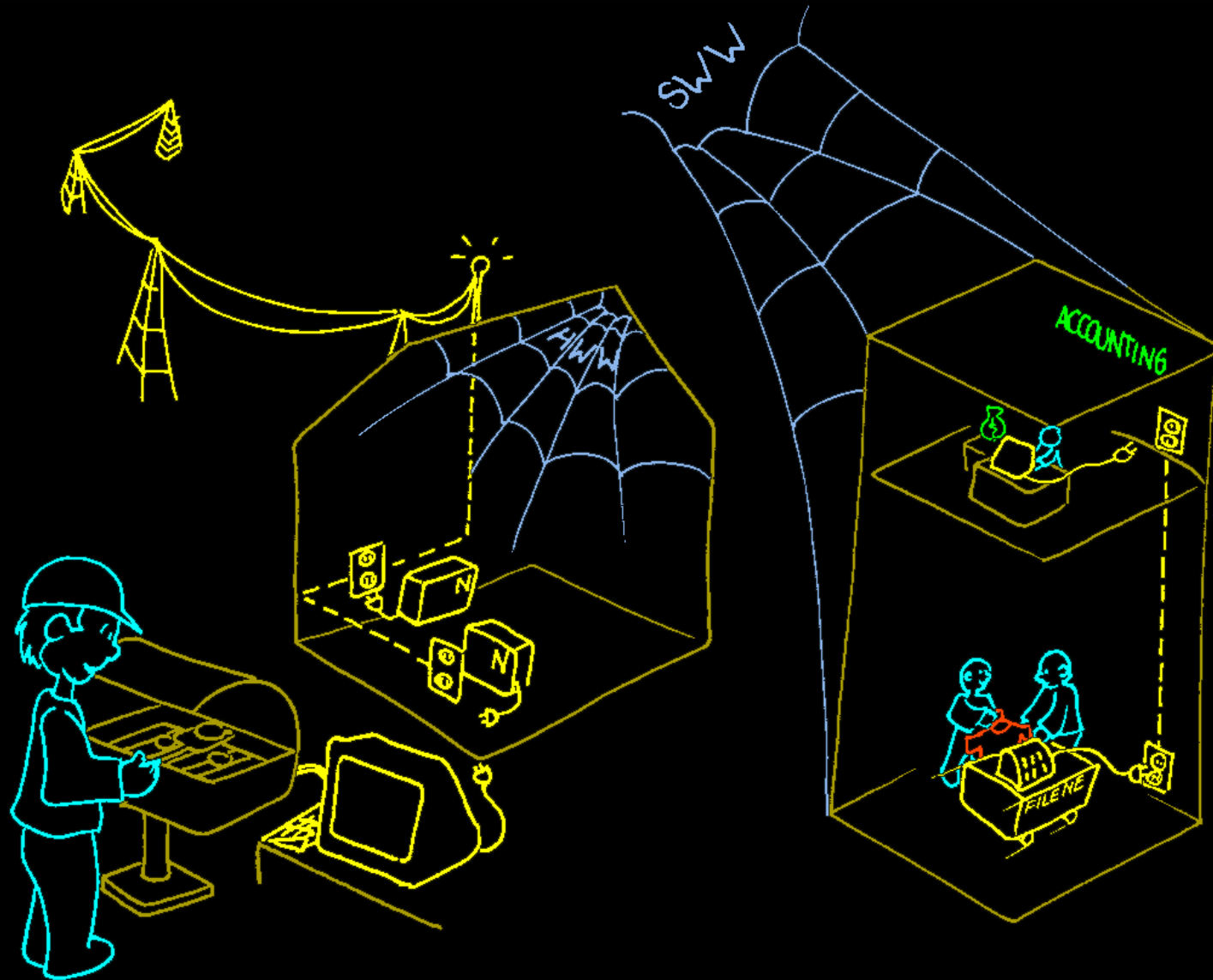
Geostationary & Geosynchronous Satellites (GEO)



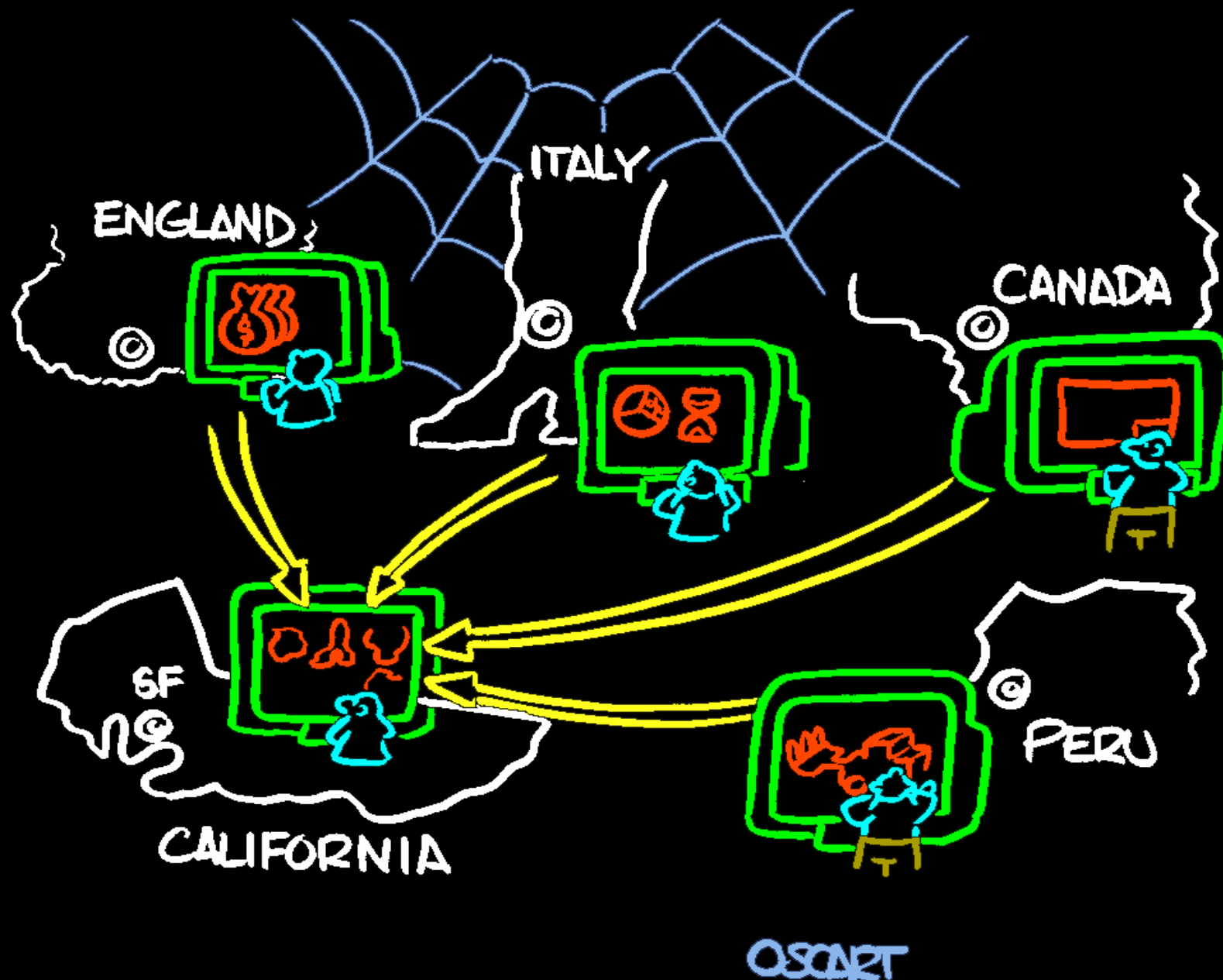
Home Network



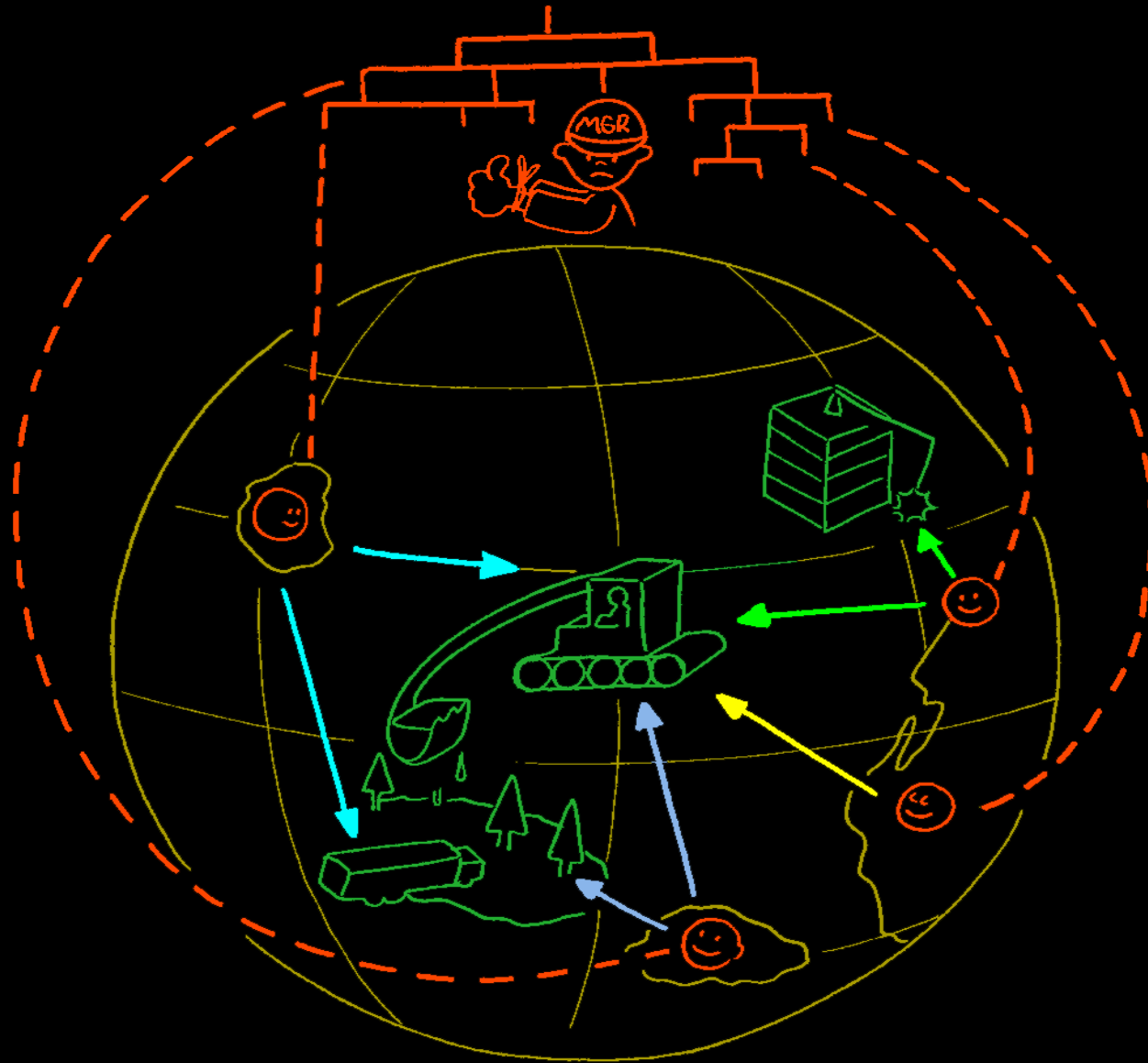
Digital Power Line (DPL)



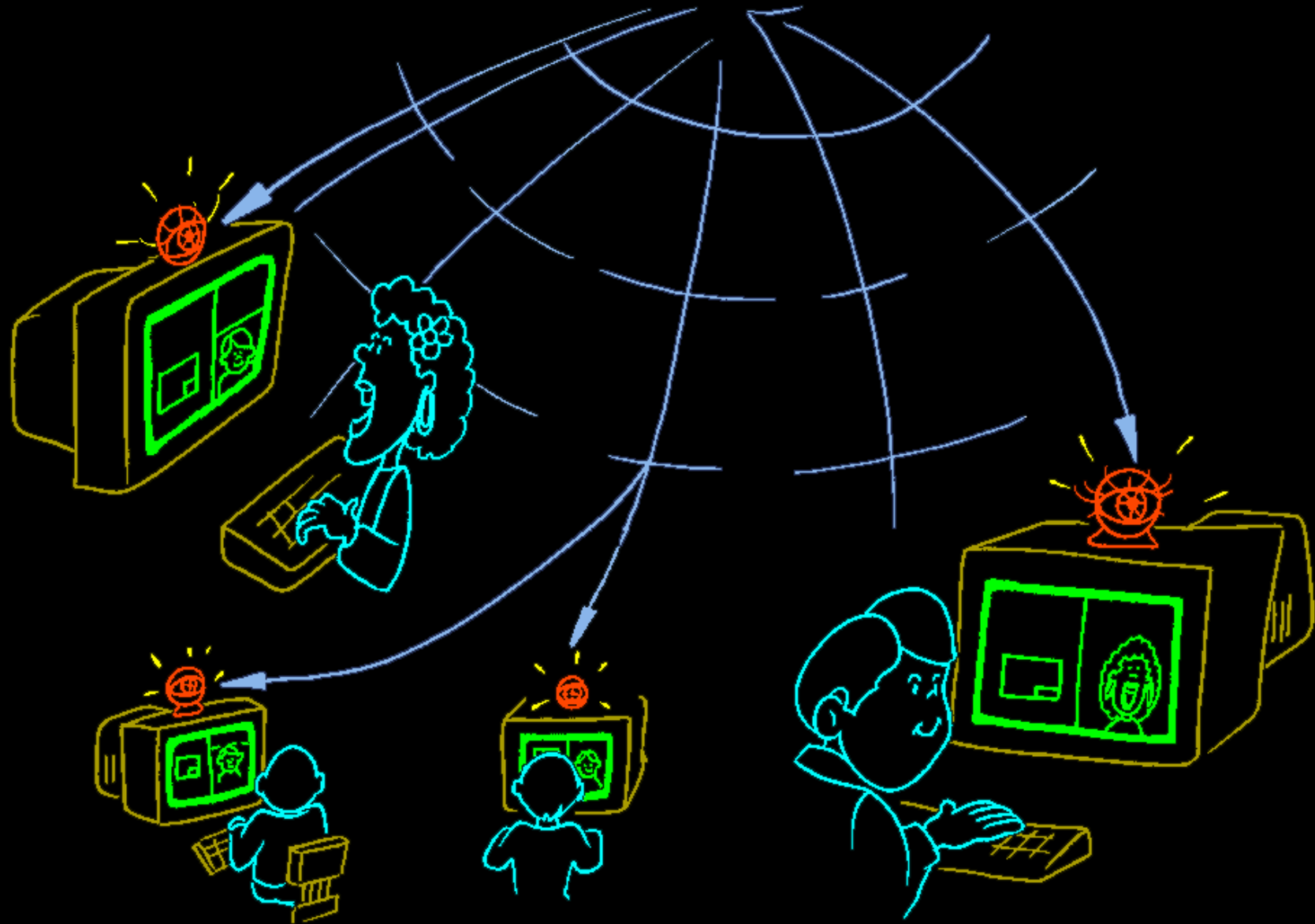
Virtual Project Team



Hyperlinked Organization



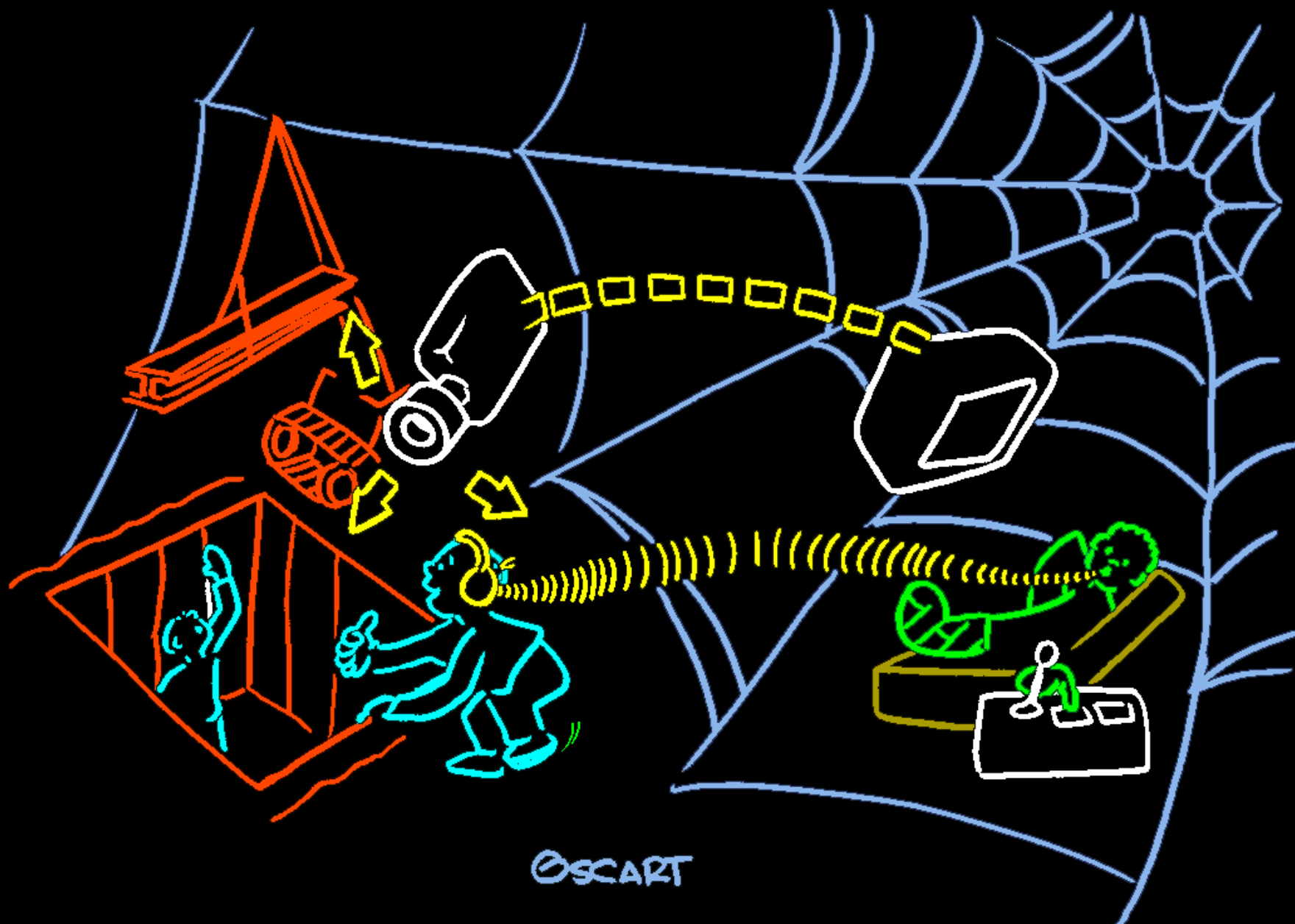
Desktop Video Conferencing



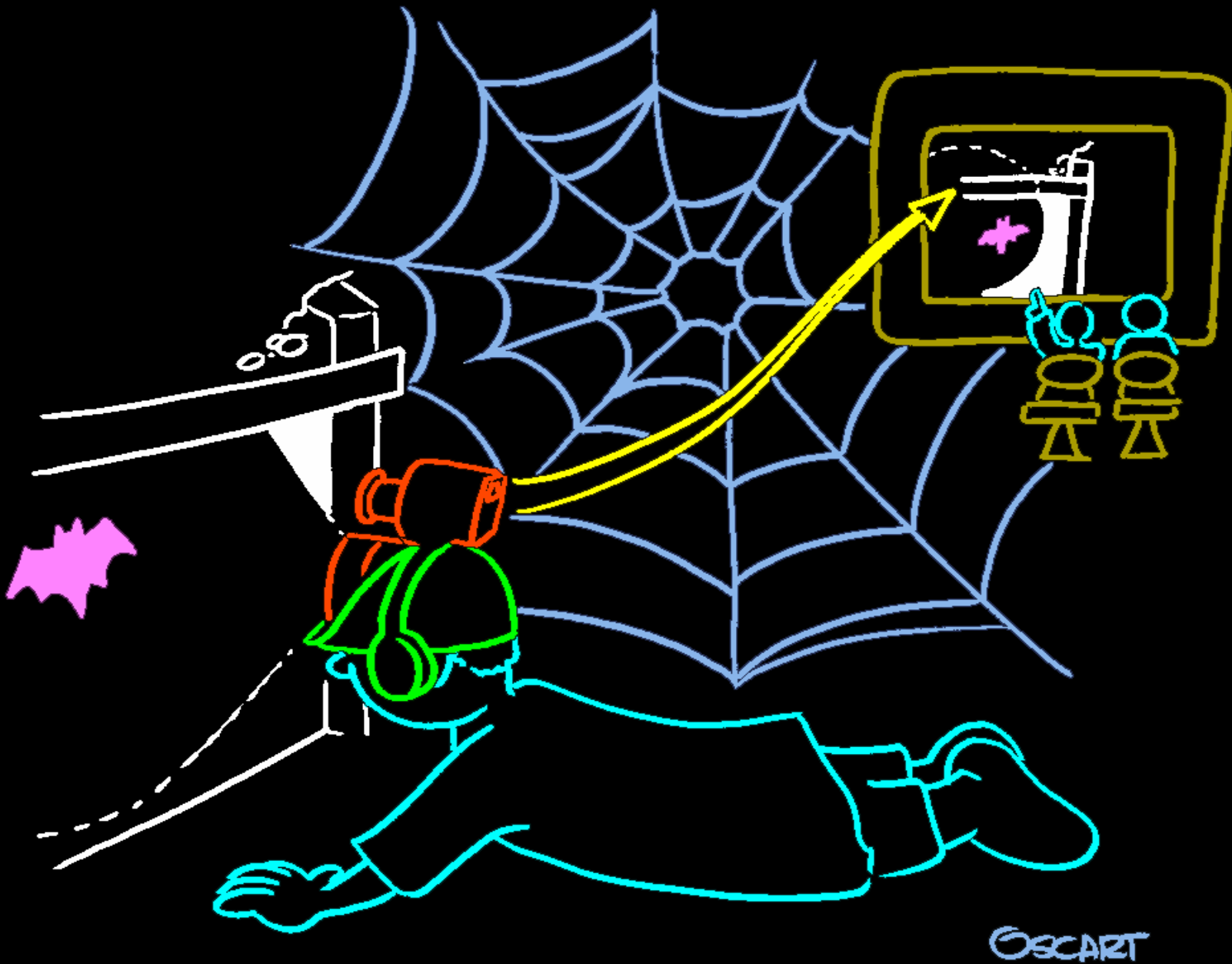
Real-Time Collaboration



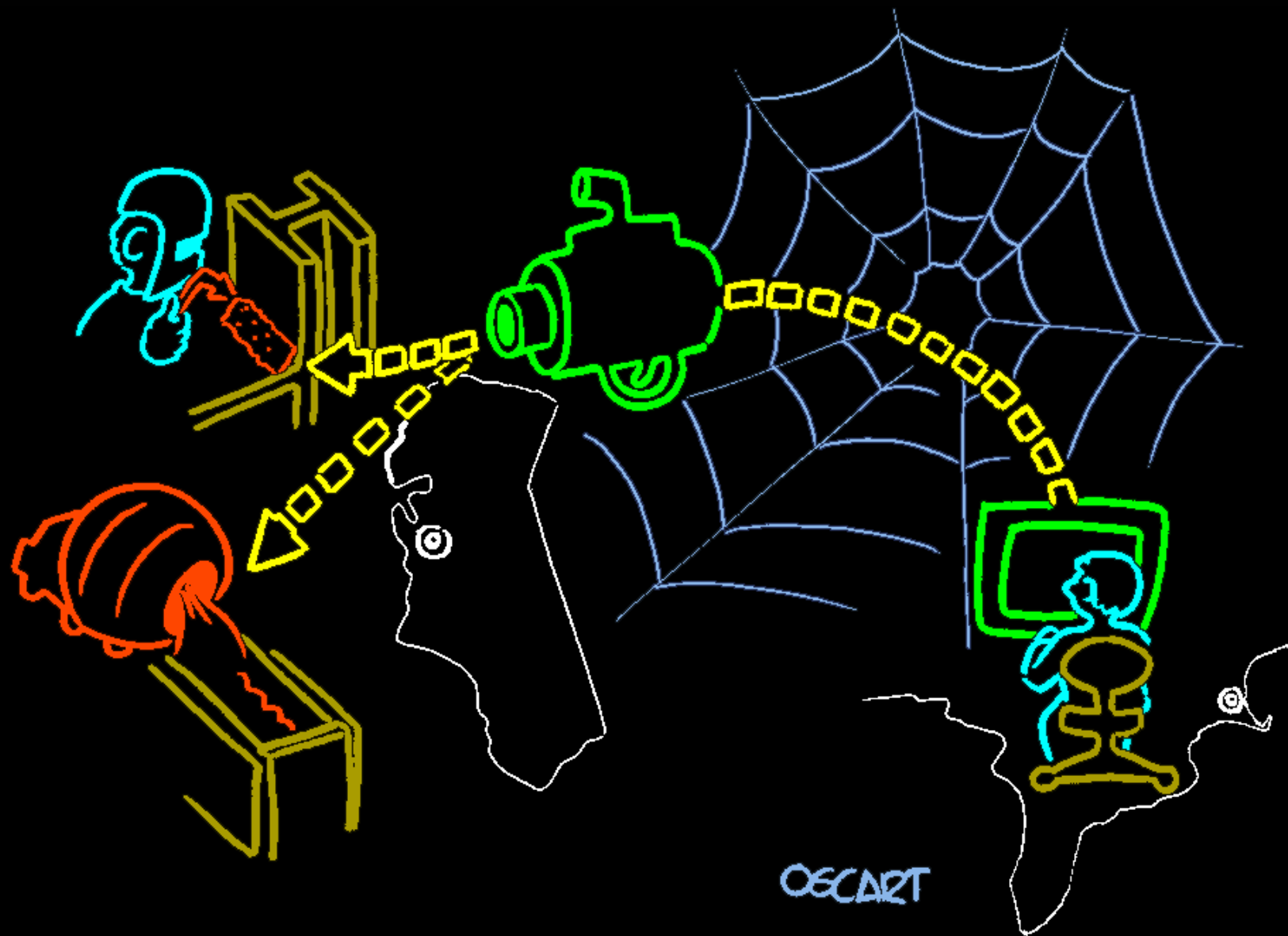
Site Cam



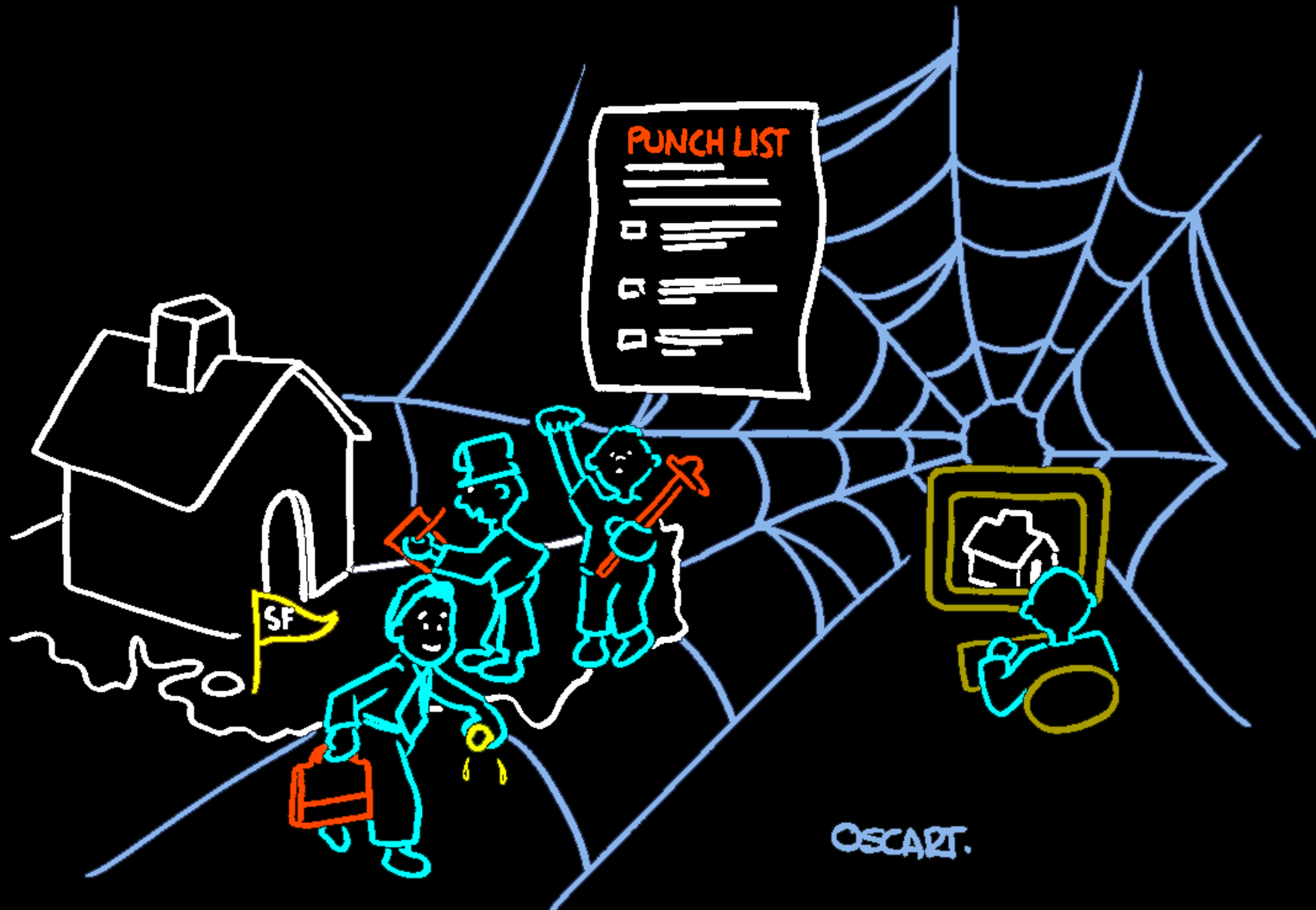
Hard Hat Camera



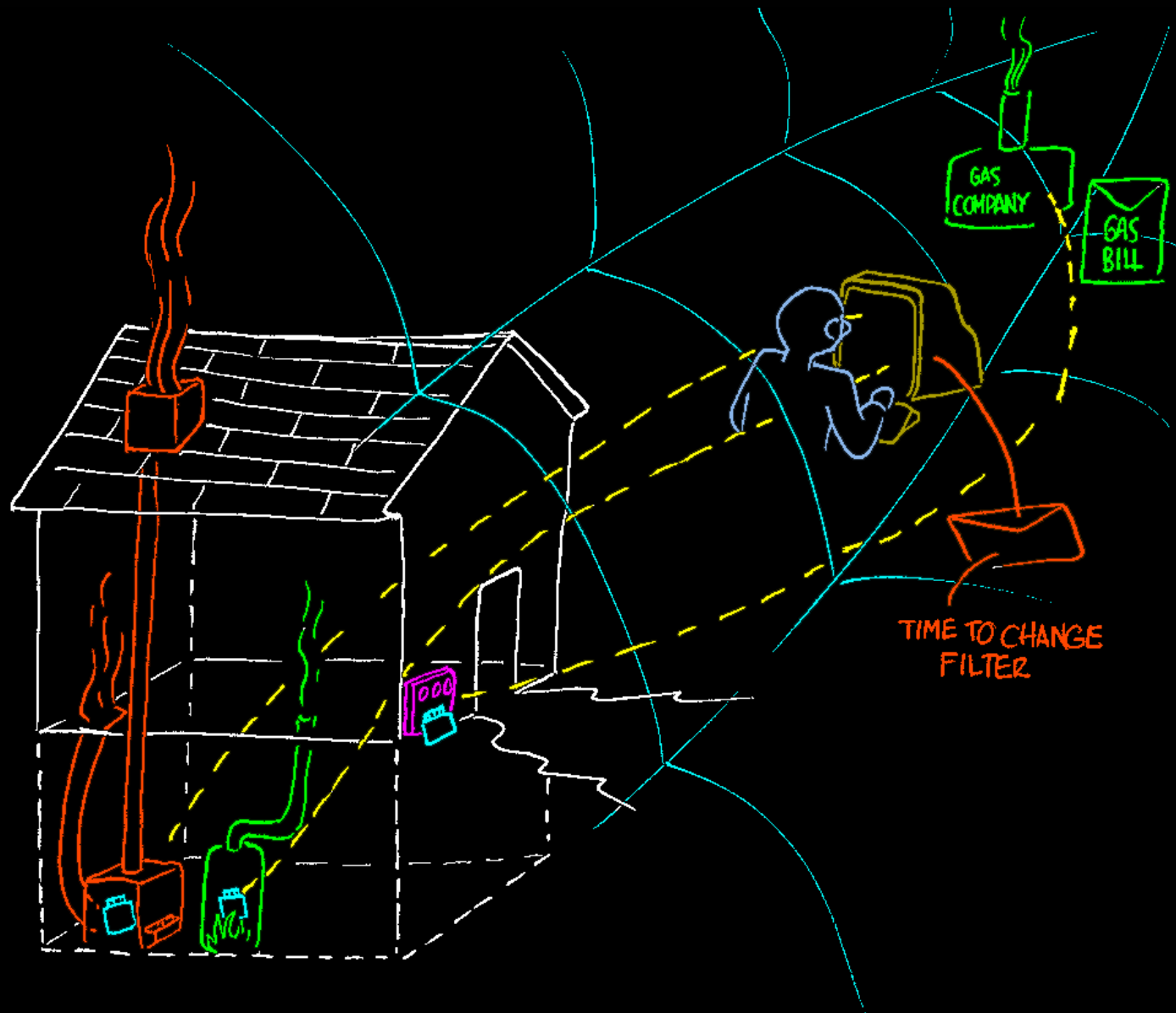
Remote Field Testing



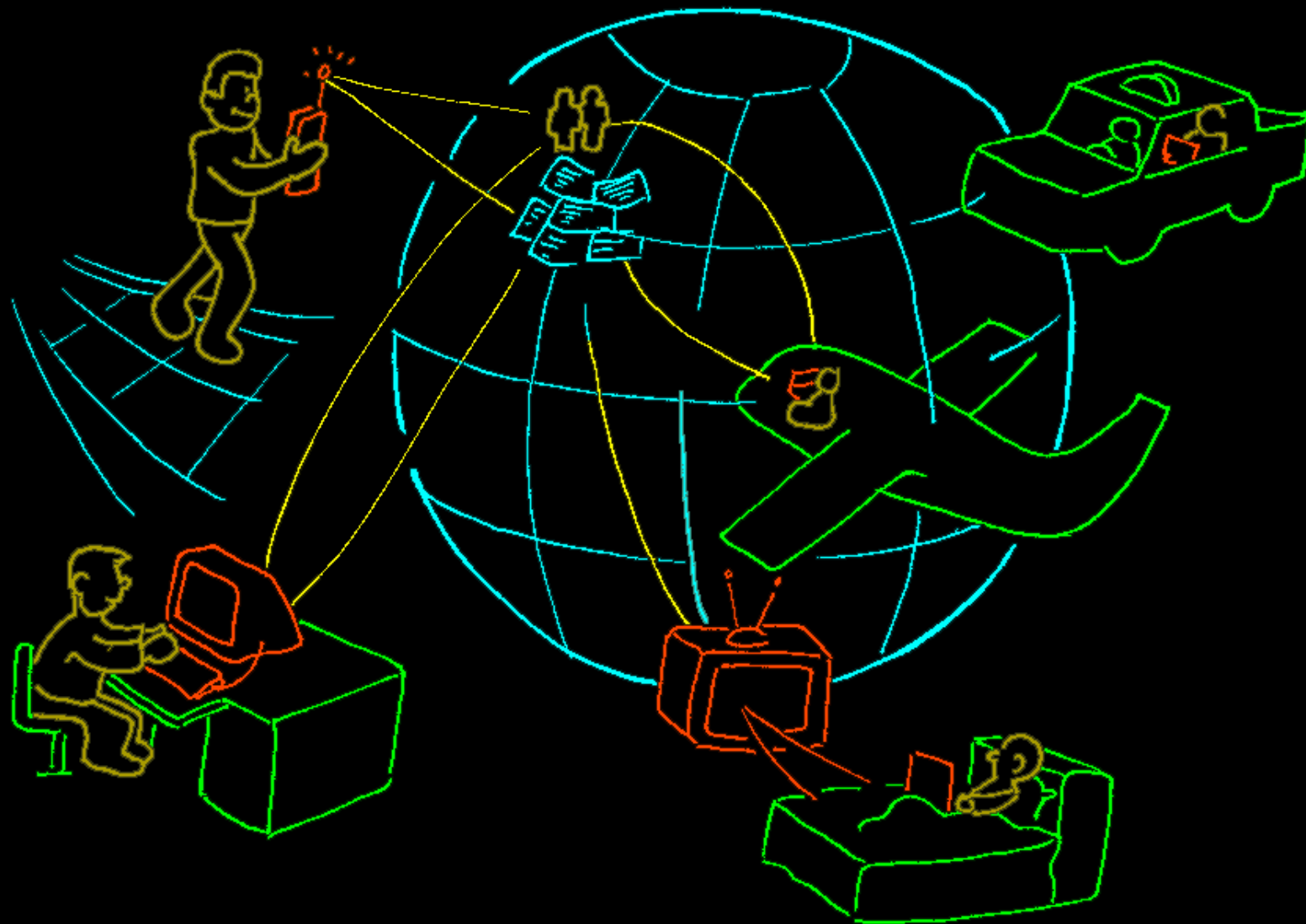
Punch List



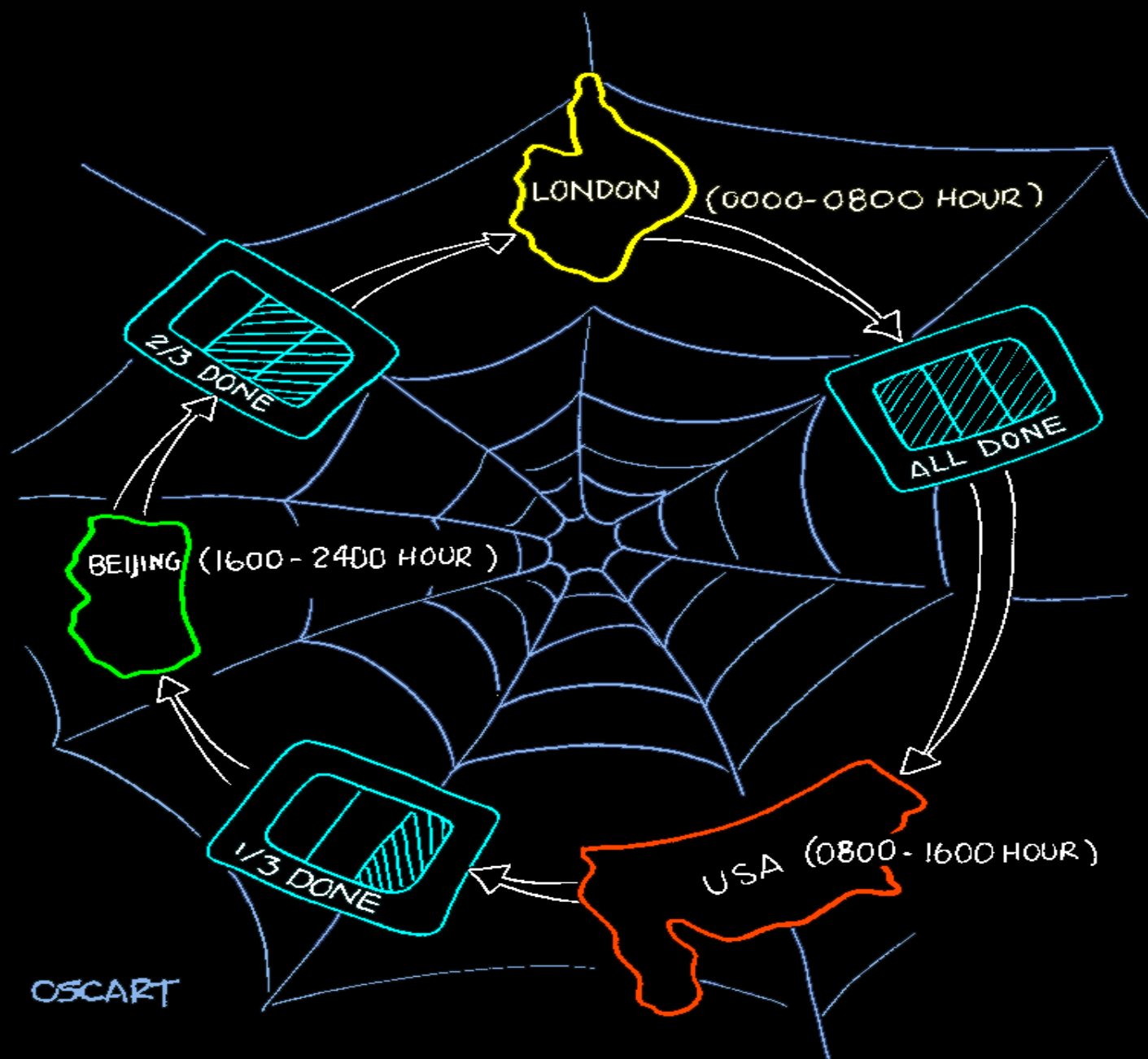
Remote Reading & Sensing



Universal Connectivity



24 Hour Operation

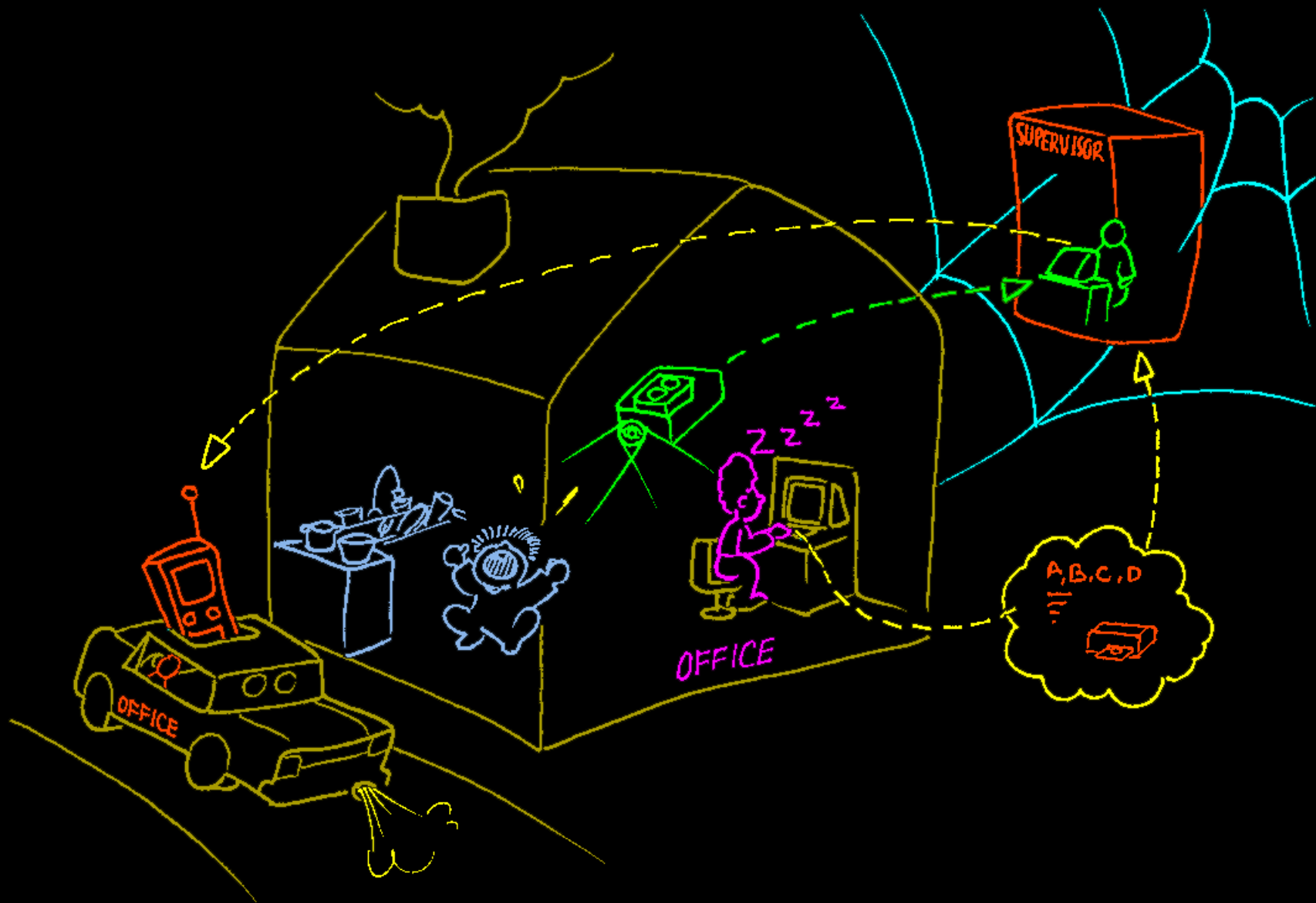


Shift Turnover Video Diary

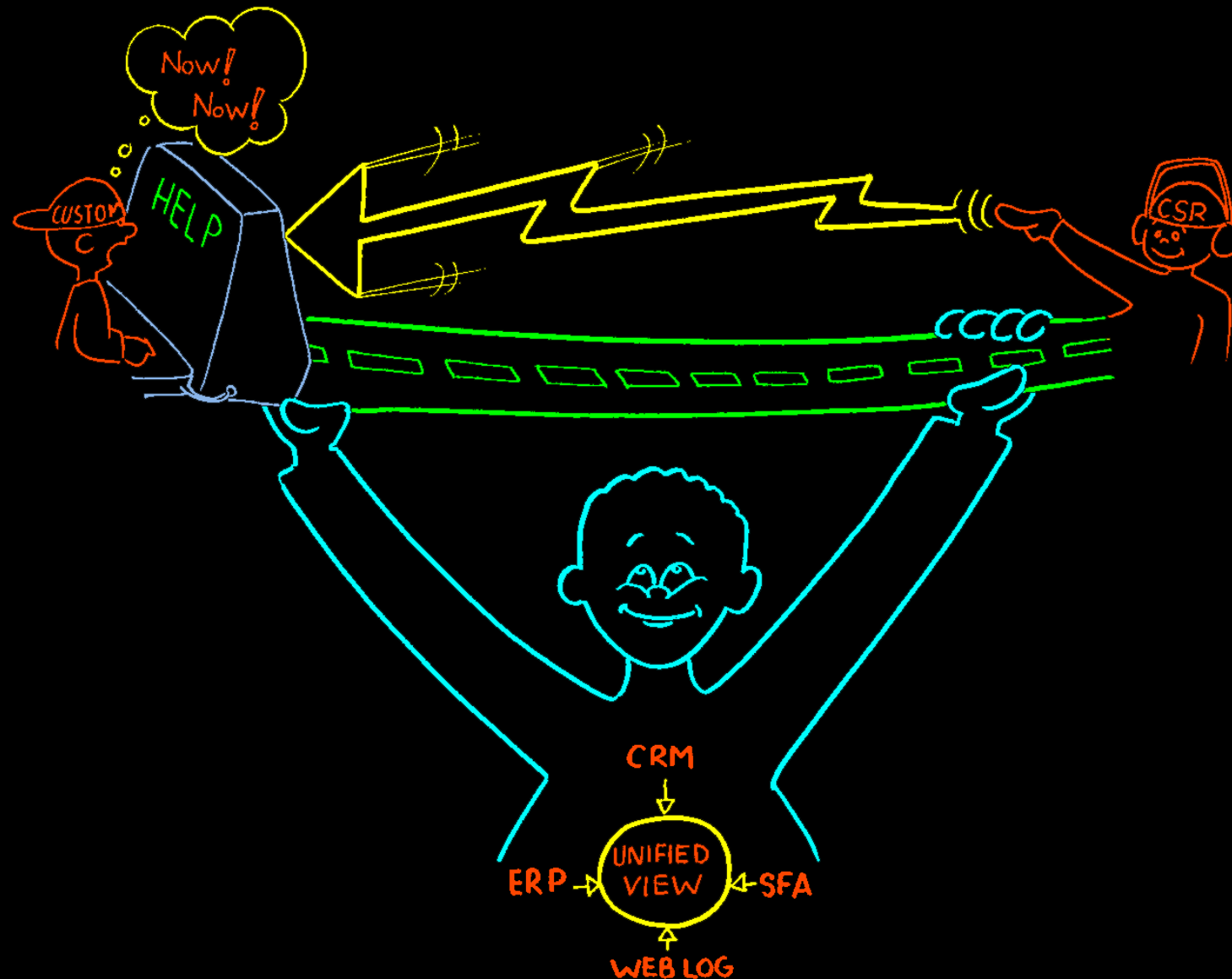


OSCAR

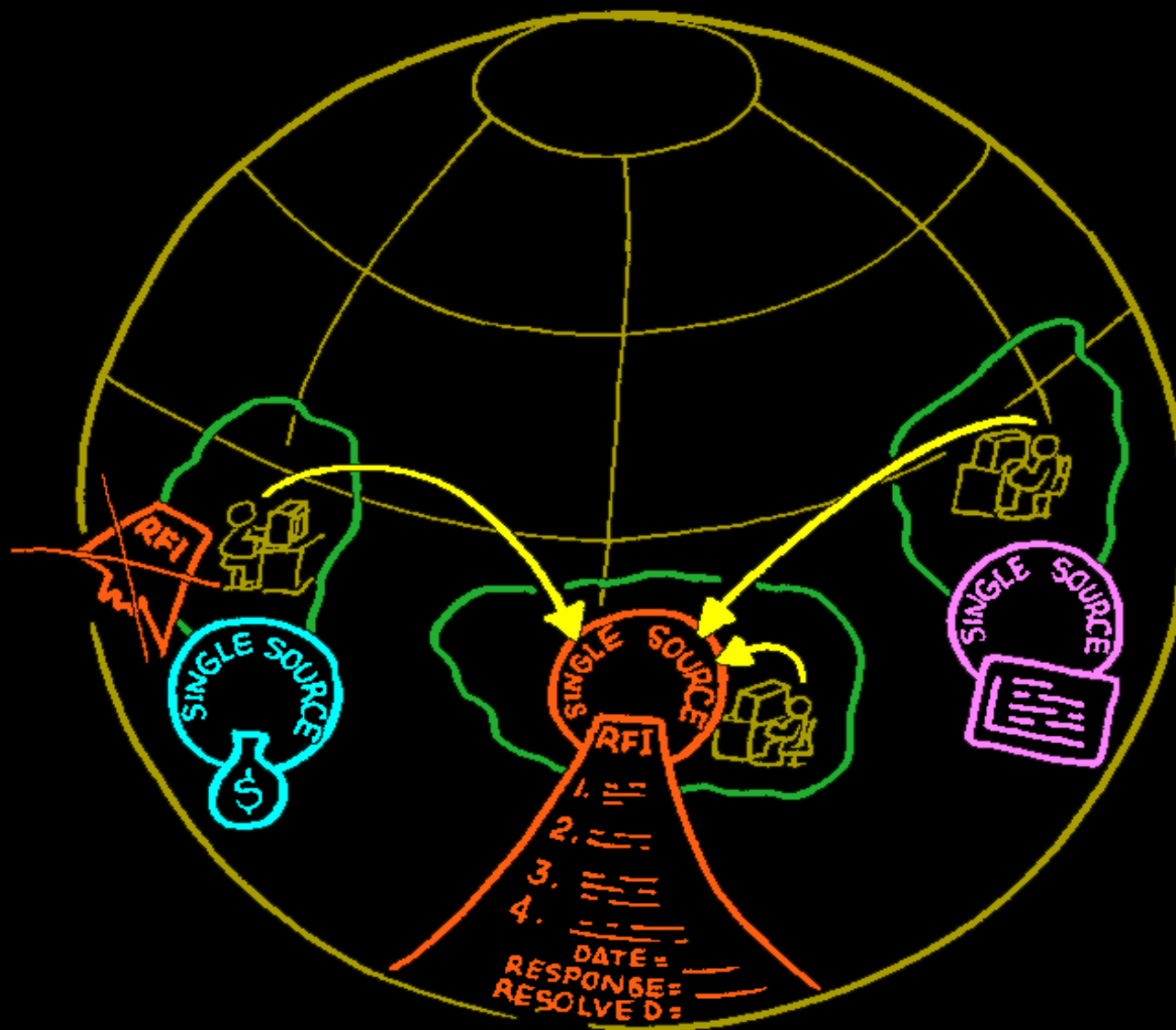
Telecommuting



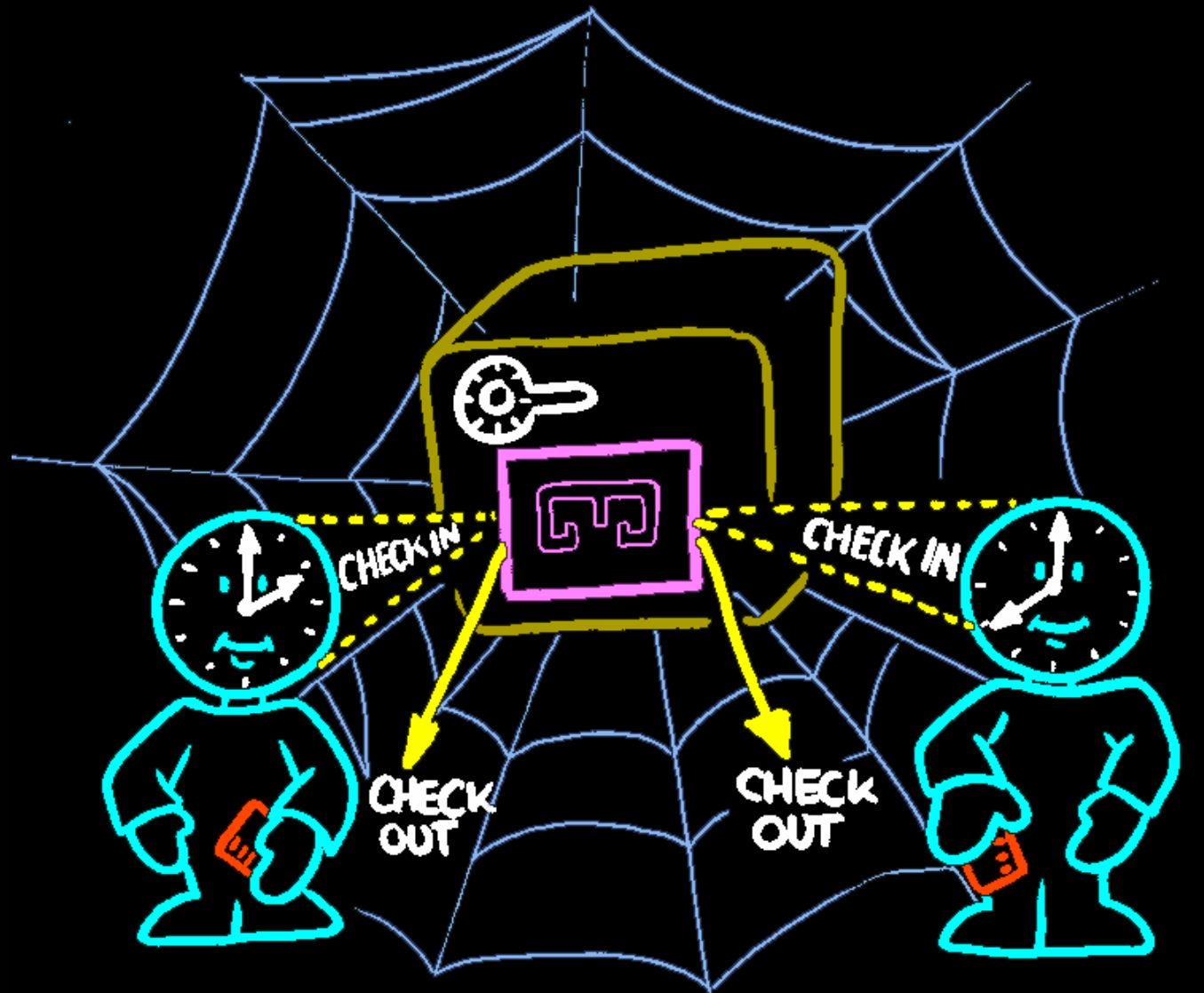
Be a Real-Time Enterprise



Single Source

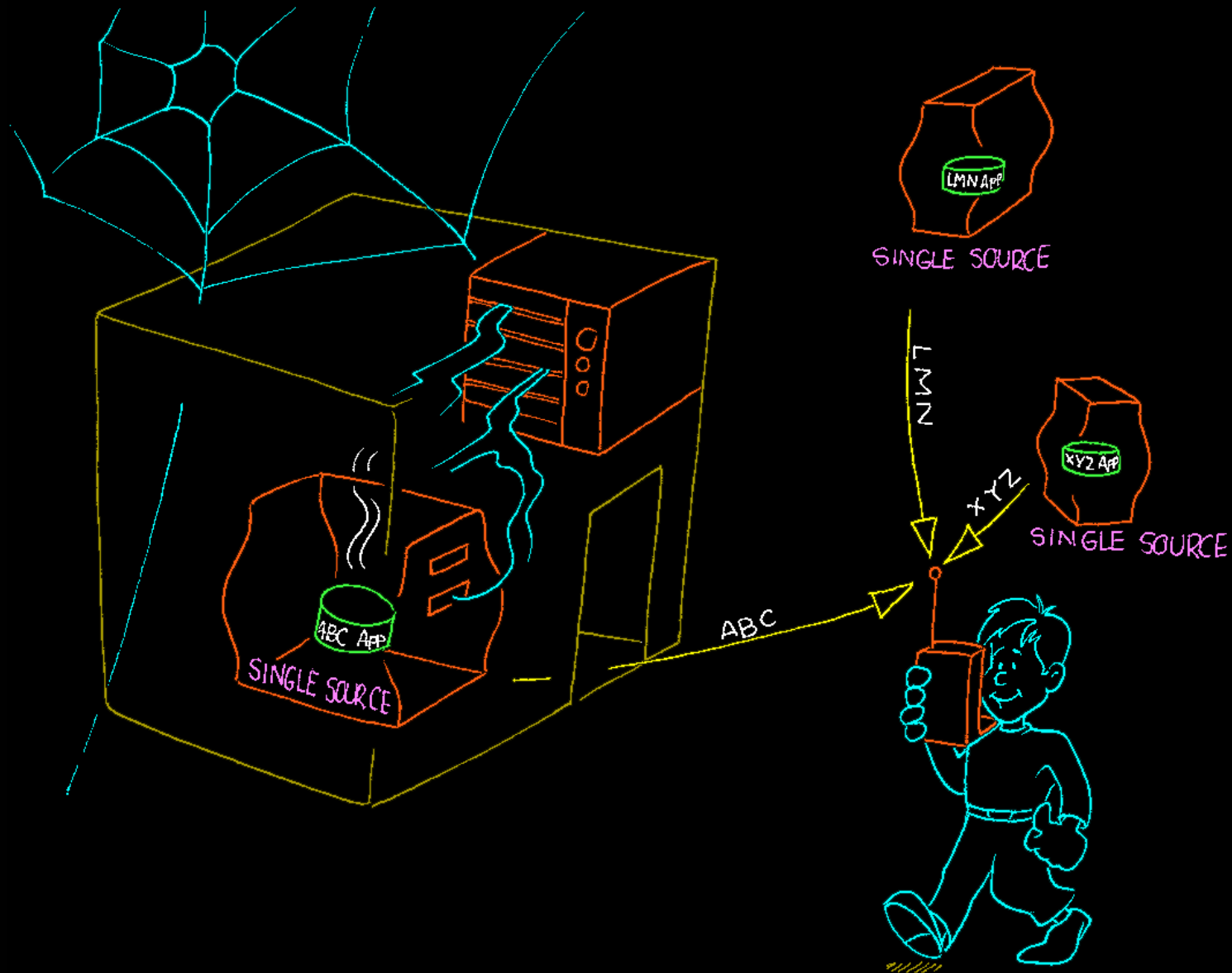


Check In & Check Out

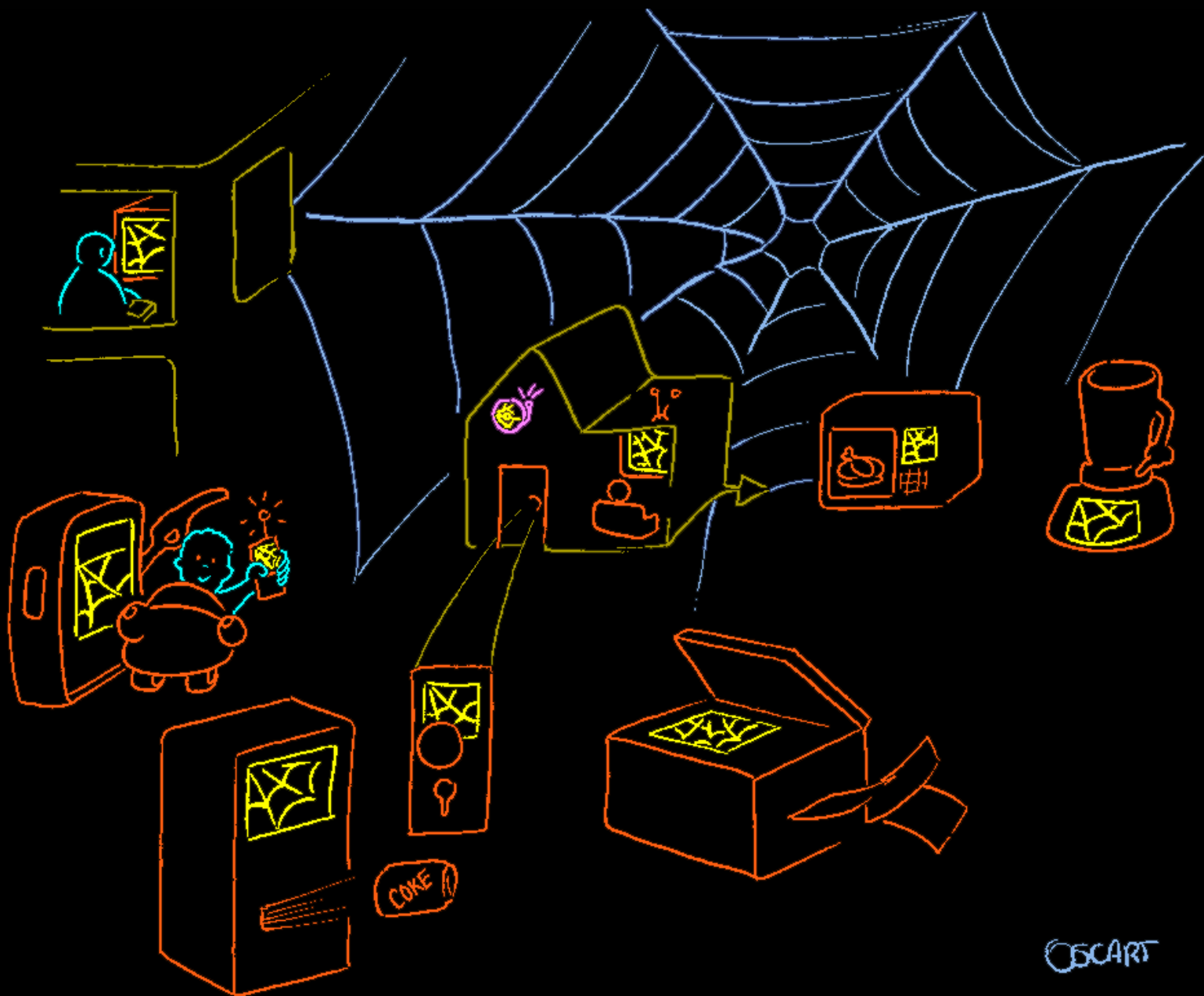


ESCART

Re-Centralization



Distributed Information Devices



OSCAR

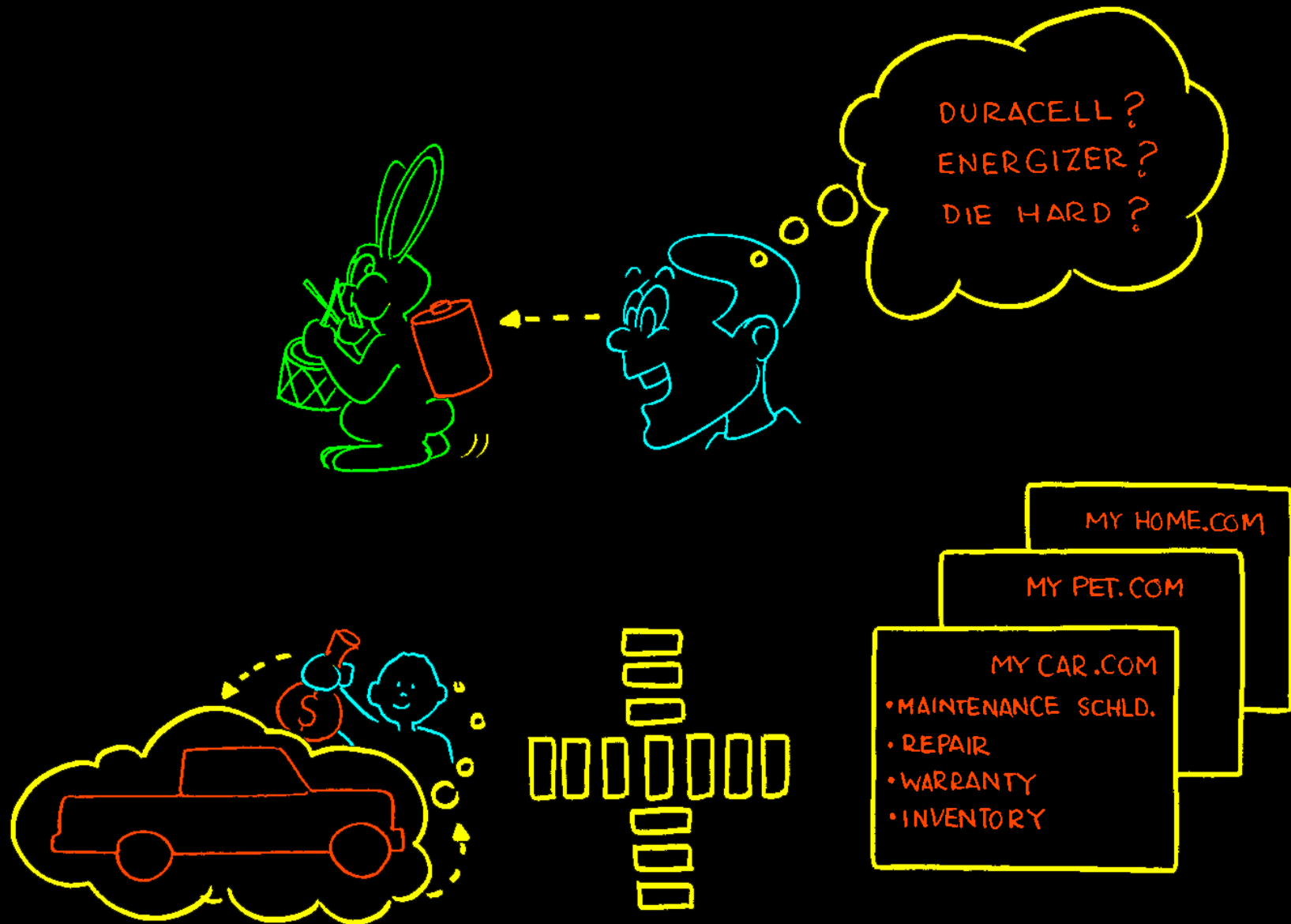
Broadband Applications

- **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**

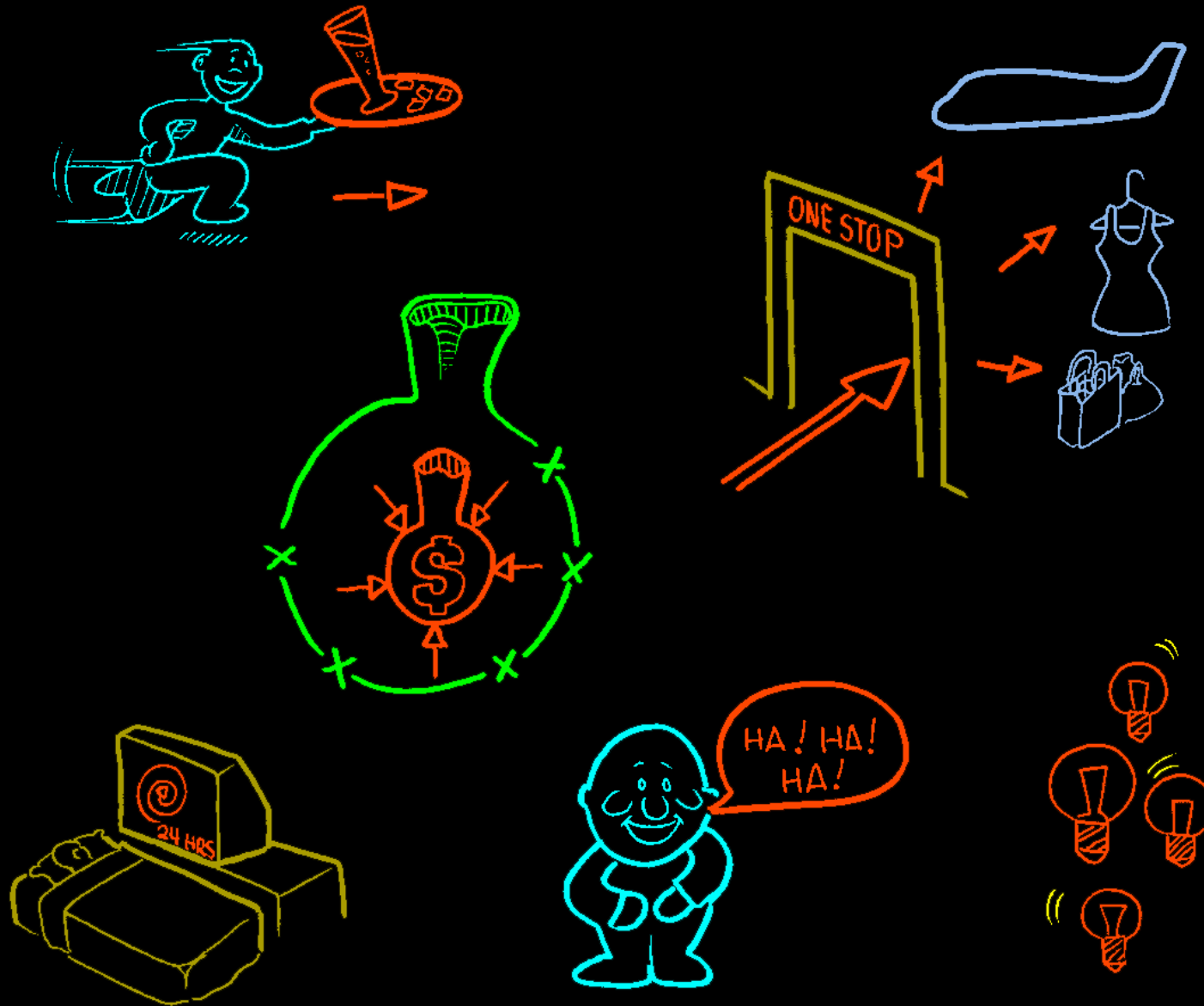
Future Home Bandwidth

- **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

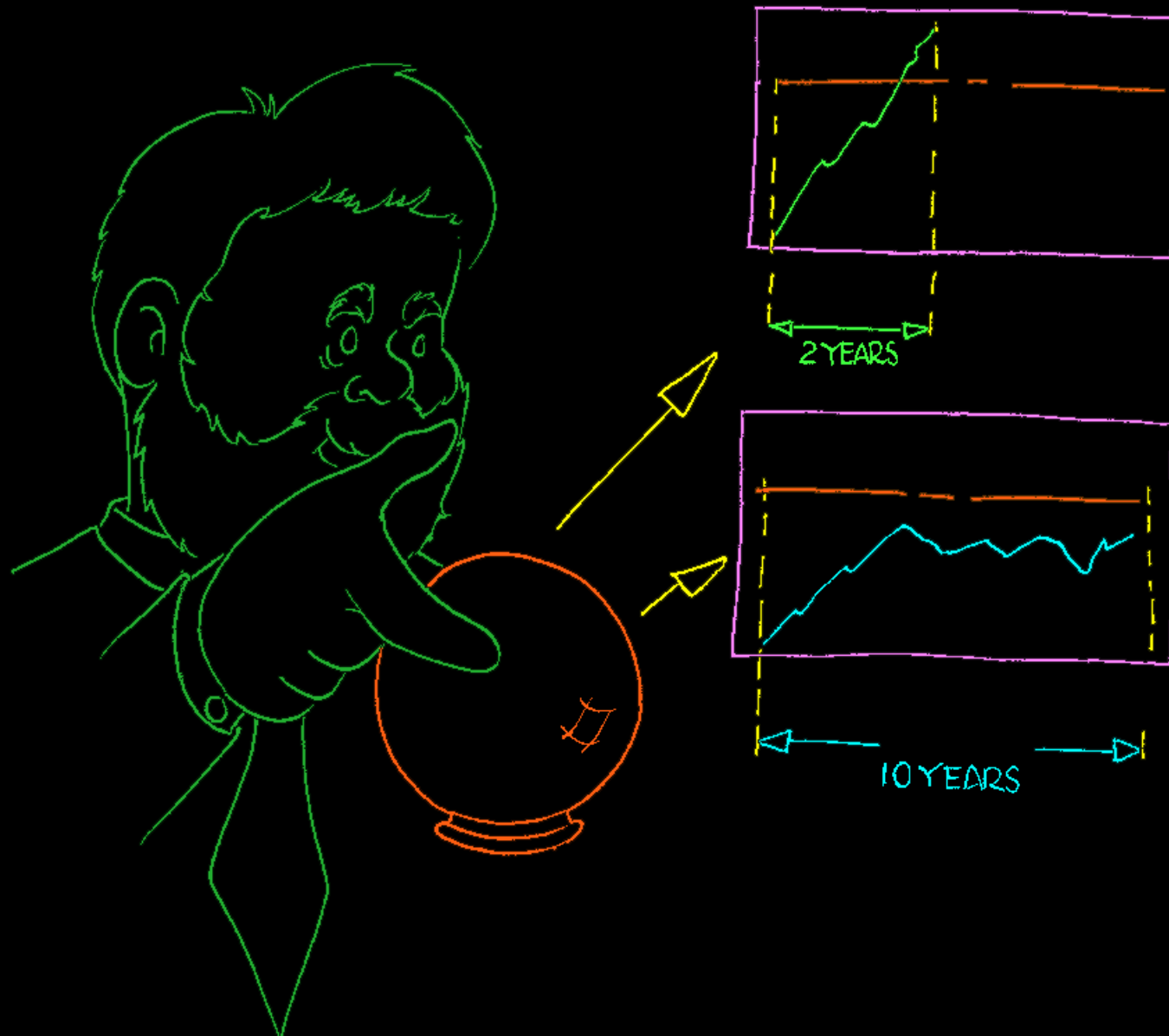
Differentiation



Competitive Advantage



Technology Revolution



Thank You



OSCAR.T