# Synchronization in the Rural Central Office Environment

## NIST 2004 Workshop on Synchronization in Telecommunication Systems

# Contact Information

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# Synchronization in Rural Central Offices

- Short Course in Geography & Demographics
- Telecommunications in Alaska
- Synchronization in Rural Central Offices

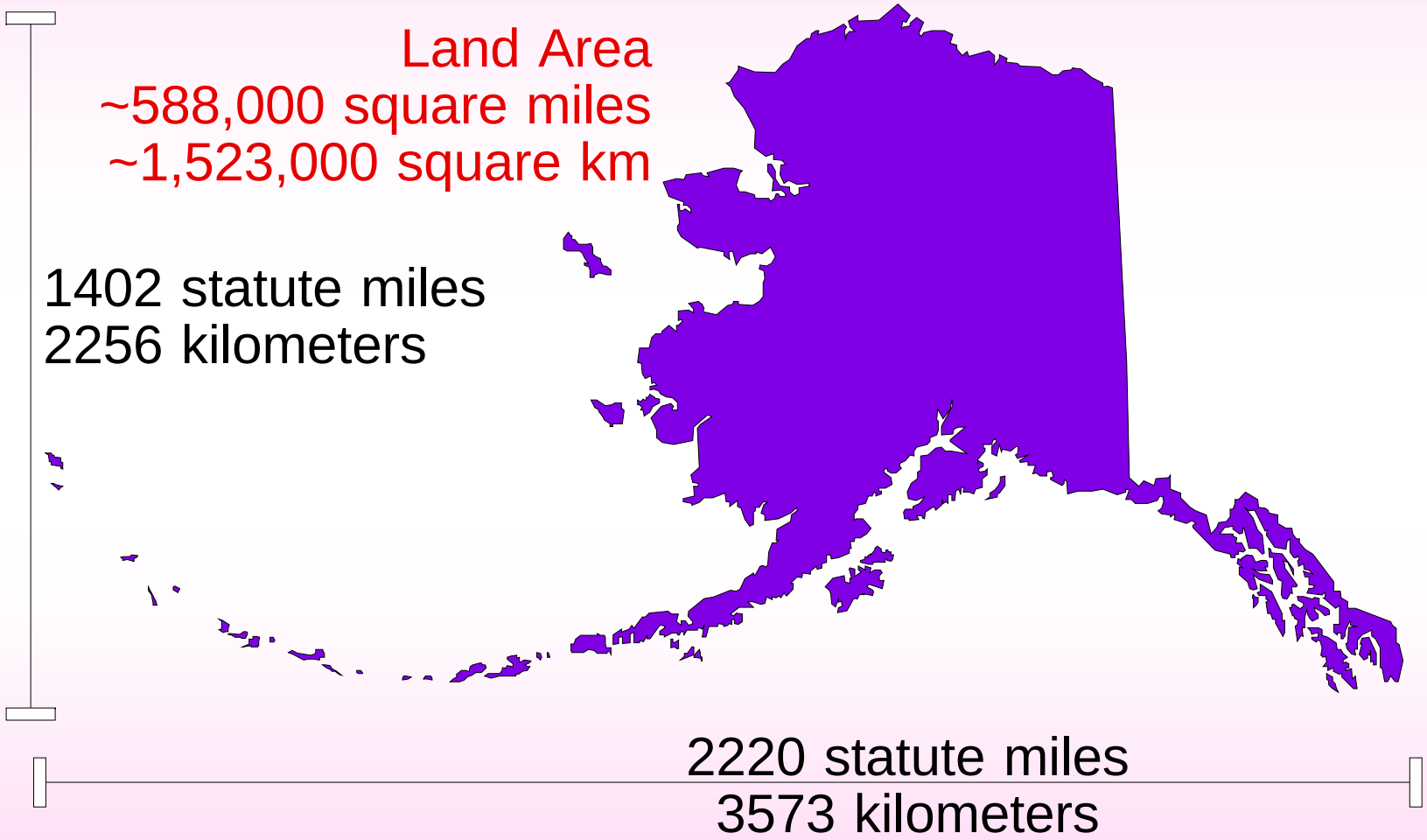
# Where is Alaska?

- Mostly in the Western Hemisphere (part of it stretches into the Eastern Hemisphere)

# Where is Alaska?

- In North America

# How Big is Alaska?



# Some other Facts about Alaska

- Largest state (by far)
- Farthest north, east, & west of all United States
- More coastline than the rest of the US combined
- At one time Alaska had four time zones
  - Pacific, Yukon, Alaska, Aleutian
- ~640,000 population (about half in Anchorage area)
- 17 of 20 highest US mountains
- Highest recorded snowfall (975”, 25 m)
- America’s biggest earthquake (1964)
- Major industries: oil, seafood, tourism, mining

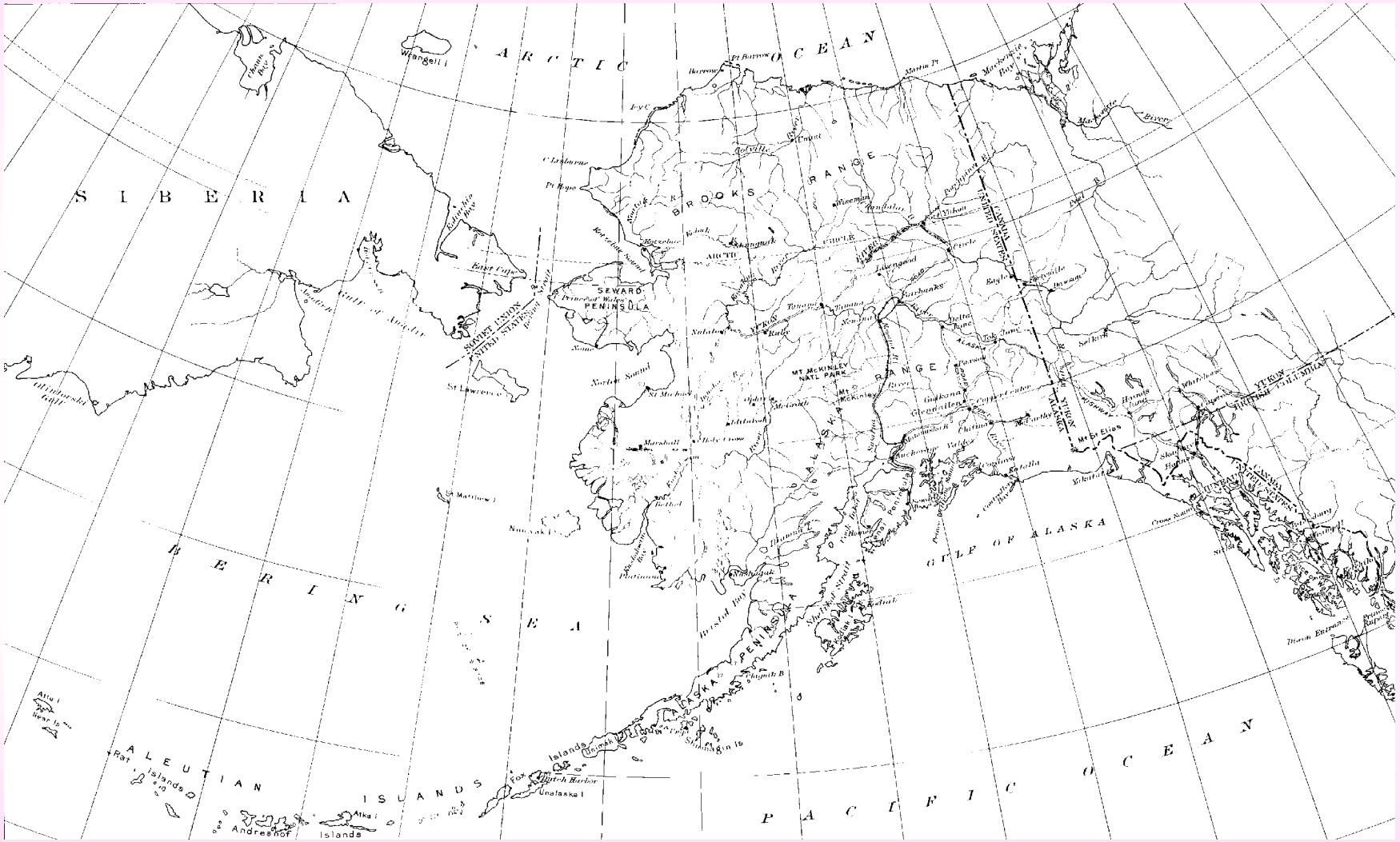
# Travel to Rural Areas

# Travel to Rural Areas

# Some Alaska Telecommunications Facts

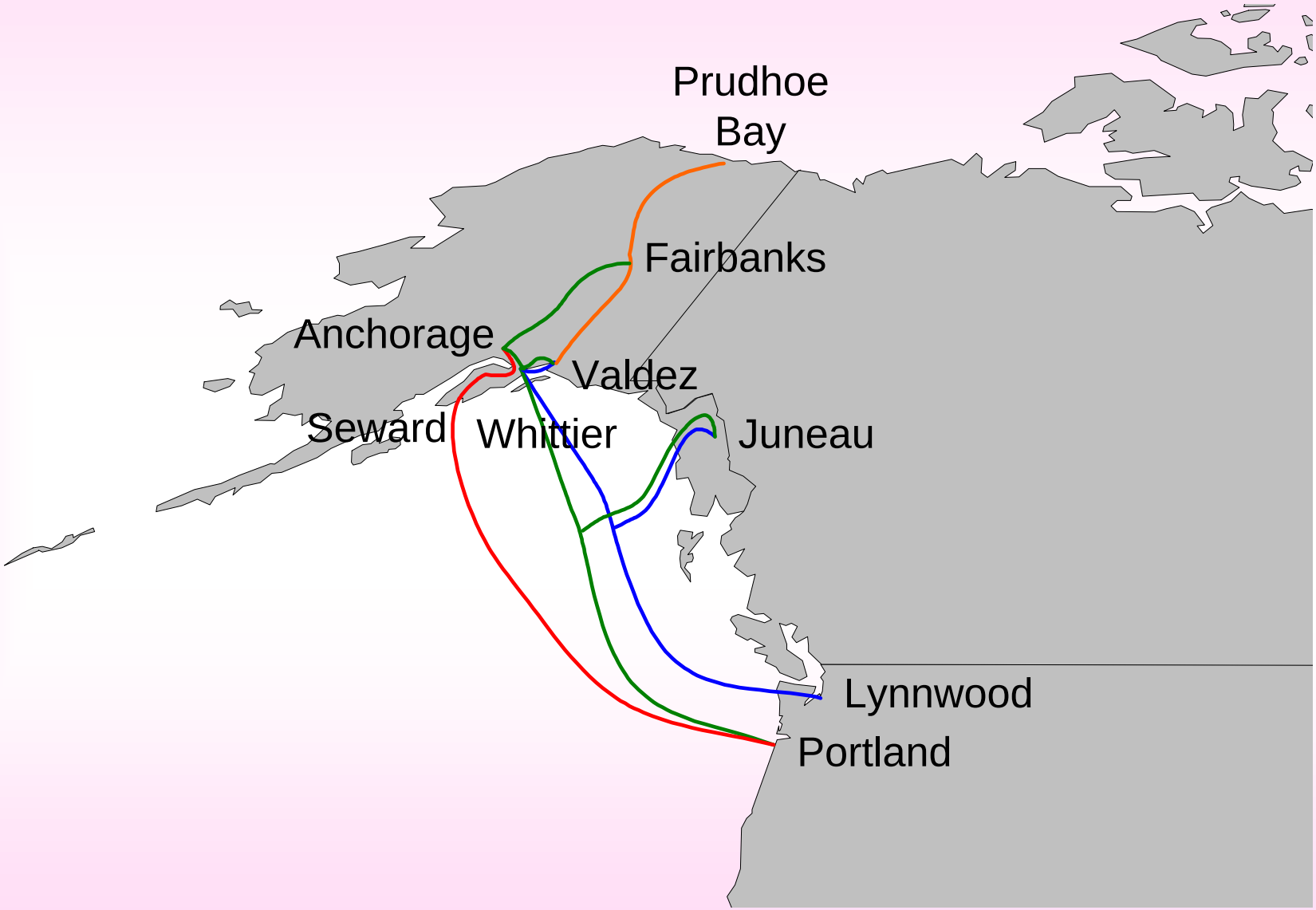
- All local telephone companies are *Independent* (no Bell Operating Companies)
- ~20 Network Operators
- ~254 Central Offices
- ~95% Household Telephone Penetration
- ~482,000 End-User Telephone Lines
- ~170,000 Wireless Telephone Subscribers
- Every community of at least 25 persons has local and long distance telecommunications service

# Alaska



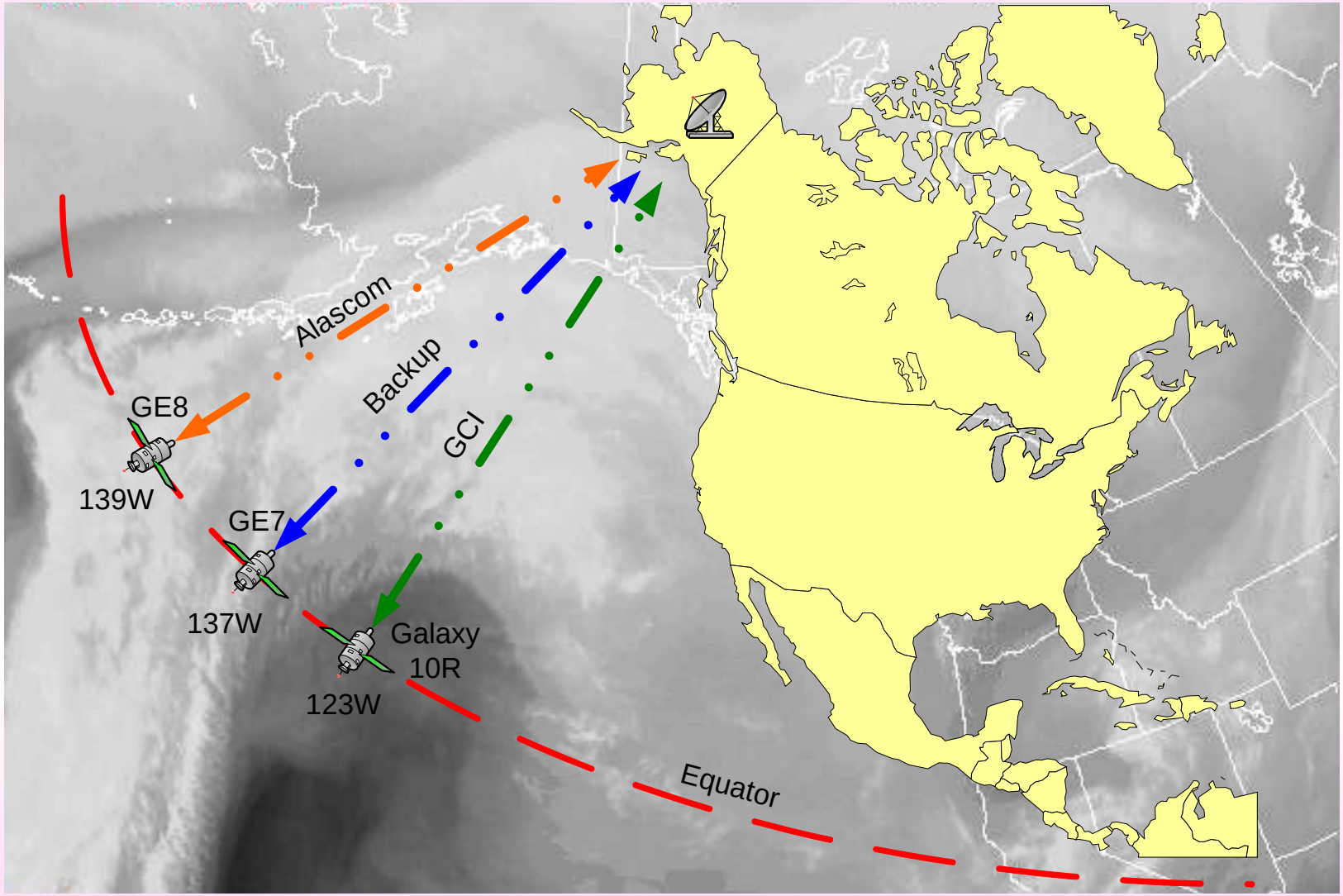
# Alaska on Telecom

# Fiber Optic Connectivity to Alaska



# Microwave Radio Connectivity to Alaska

# Satellite Connectivity to Alaska



# Small Central Office Applications

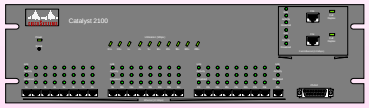
- Link from Rural Central Office to Public Network via Interexchange Carriers
  - Single Interexchange Carrier
    - AT&T Alascom Satellite Earth Station (“carrier of last resort”)
  - Two or more Interexchange Carriers
    - GCI Small Satellite Earth Station
    - GCI Large Satellite Earth Station
    - AT&T Alascom Satellite Earth Station
    - AT&T Alascom Terrestrial Microwave Radio
- We need to know the interexchange carrier’s configuration so we can properly design the synchronization method

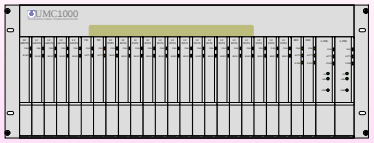
# Small Central Office Applications

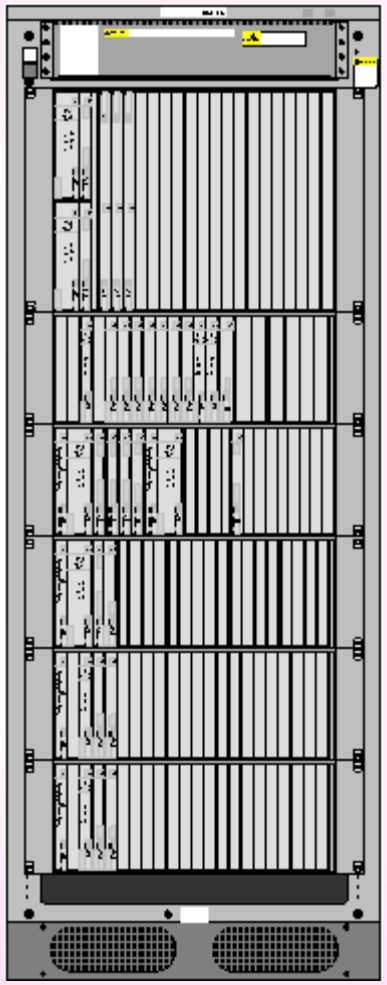
- Geostationary satellites present particularly challenging synchronization problems
- Orbit characterized by
  - Inclination angle relative to equatorial plane
  - Orbital eccentricity
  - East-west drift
- Doppler shift with respect to DS-1 (1.544 Mb/s)
  - Plesiochronous operation requires 4,000 bit sync buffer
  - Loop-timed operation requires 7,000 bit buffer
  - Higher level multiplexers buffer entire multi-frames

# Small Central Office Applications

- Small central offices characterized by
  - Limited number of digital network elements
  - Centered on a circuit-switching system (end office)
  - Other digital network elements
    - 1/0 digital cross-connect system
    - DSLAM (DSL Access Multiplexer)
    - Modem server and associated internet access equipment







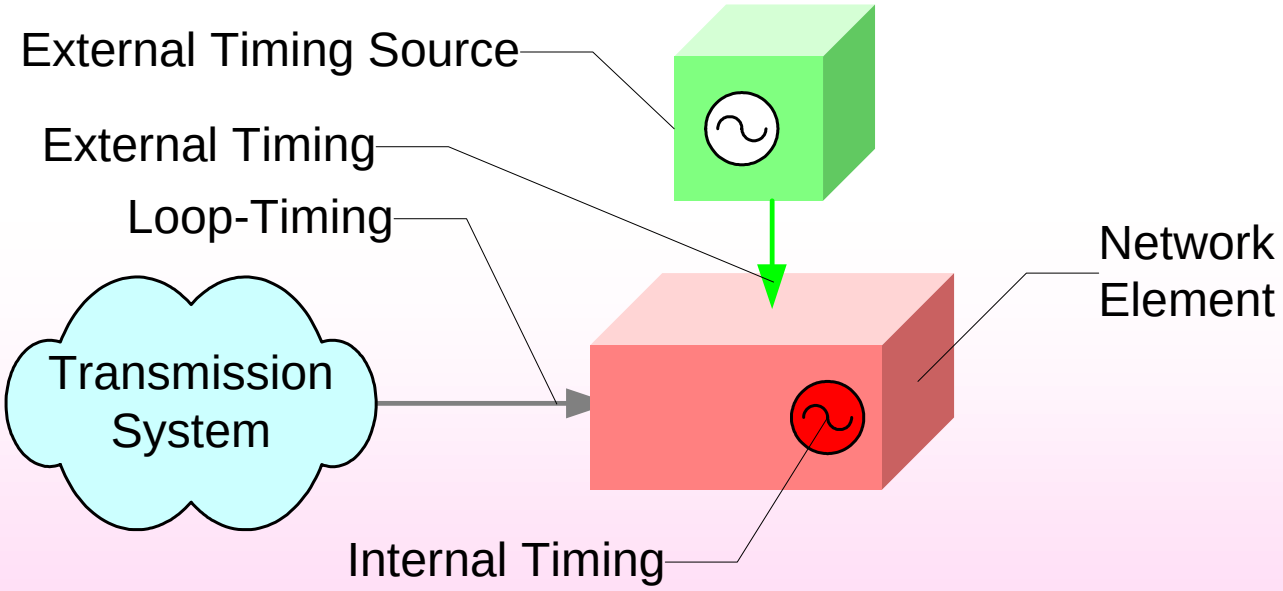
# Small Central Office Applications

- End Office Switching Systems
  - Nortel DMS-10
  - Mitel GX5000
  - Redcom MDX & MDXI
  - Siemens DCO
  - Lucent 5ESS-VCDX

- *Next Generation* Switching Systems being deployed now in Alaska
  - Taqua OCX (TDM/IP)
  - Gluon CLX (TDM/ATM)
  - Metaswitch VP3500 (ATM/IP)

# Small Central Office Applications

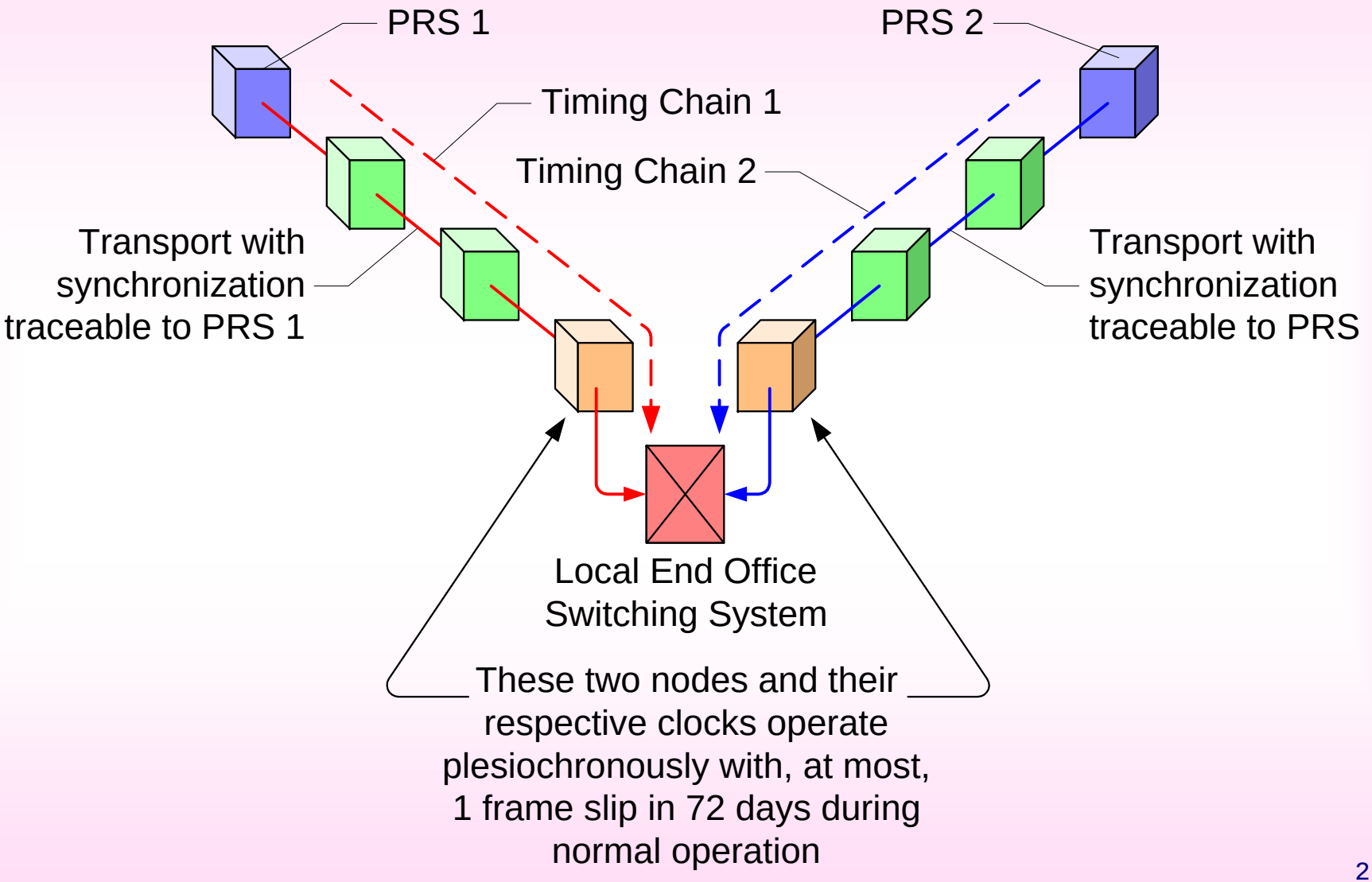
- All digital network elements require synchronization
  - Loop-timing (recovered timing)
  - External timing



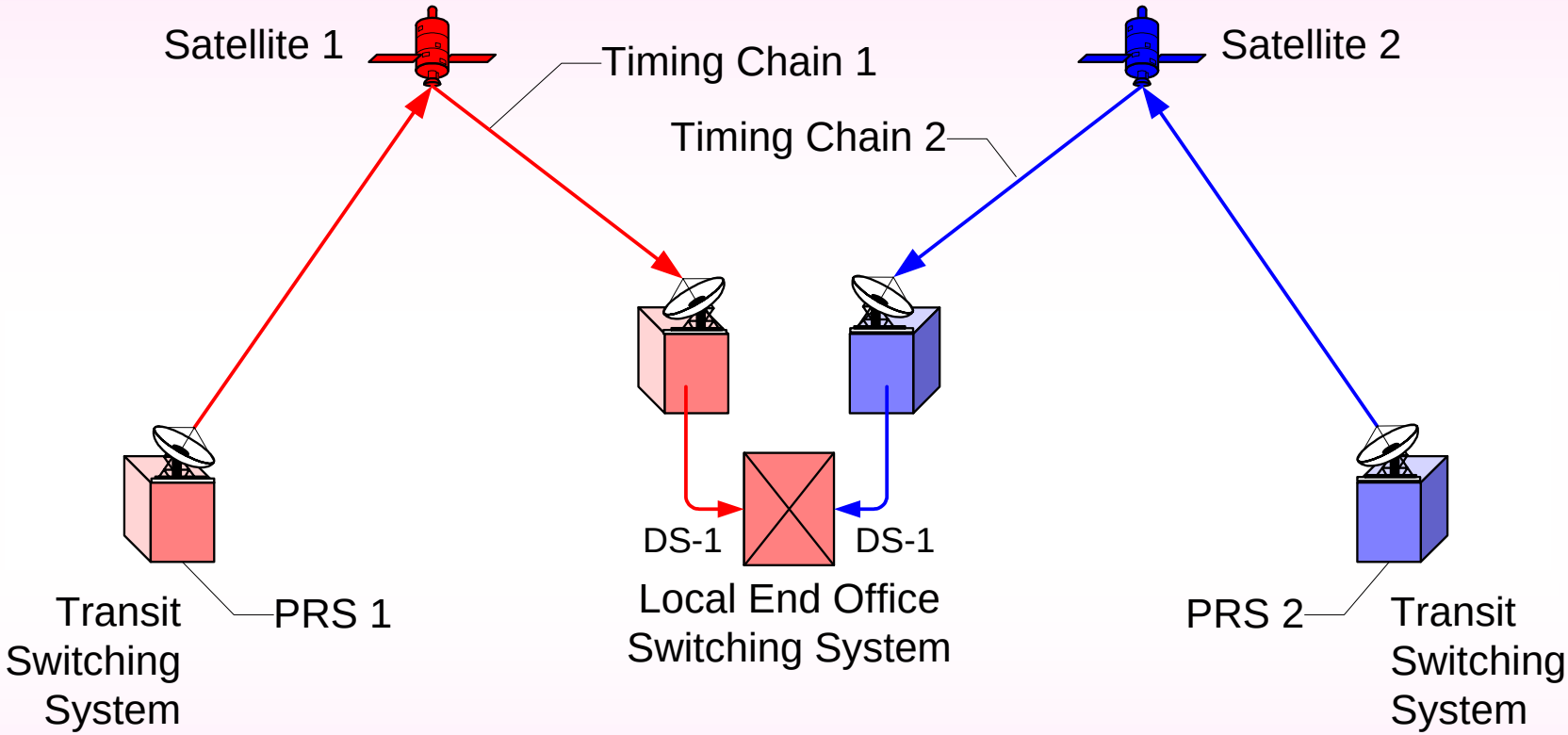
# Small Central Office Applications

- Historically, Digital Network Elements in Small Central Offices Used Loop-Timing
  - Adequate because there was only one interface to the public network via one interexchange carrier (Alascom)
- Additional carriers place facilities and interconnect
  - Synchronization requirements are more complicated and demanding
  - Carriers must be Plesiochronous
- When SS7 deployed in an End Office, local Stratum 1 traceable synchronization required

# Plesiochronous Operation



# Plesiochronous Operation

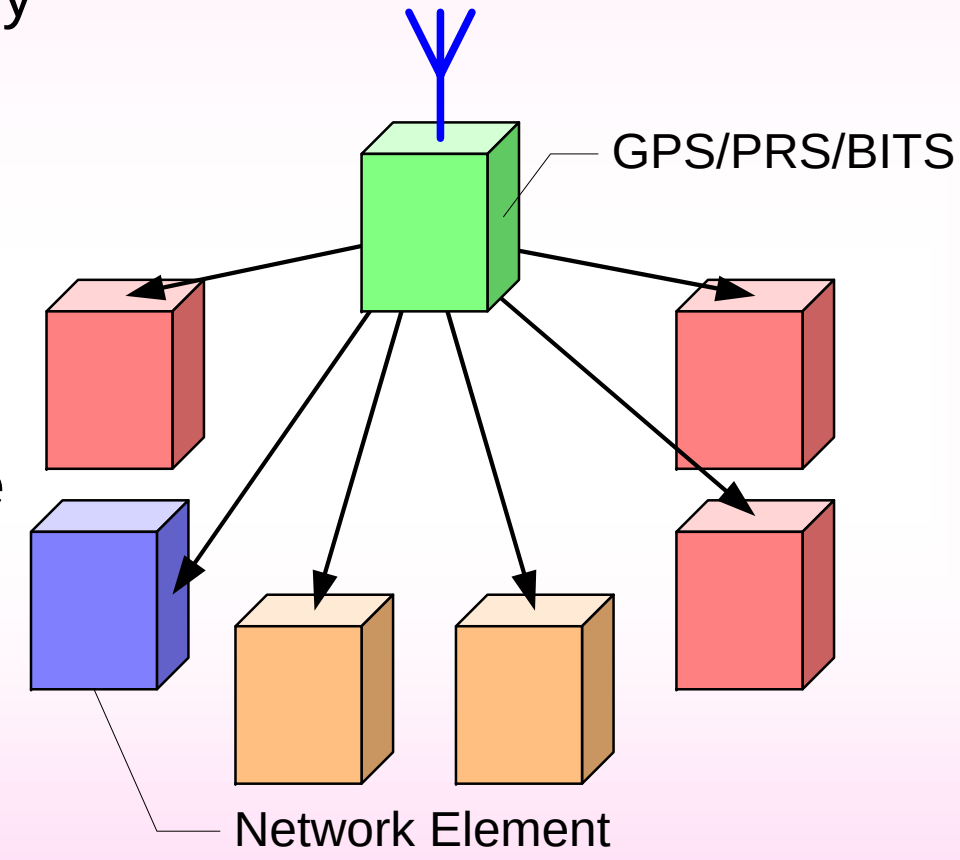


# Synchronization Signal Characteristics

- Small CO applications
  - DS-1 – Framed (SF or ESF), DSX-1 compatible, for switching system and SONET applications
  - Composite Clock (CC) – 8/64 kb/s, for primary multiplexers and 1/0 Digital Cross-connect Systems
    - Required for any network element that provides interfaces for dedicated digital services (DDS) that operate at 64 kb/s and lower
    - Circuits used for SS7 signaling links
  - Some end office switching systems require 10 MHz sinewave (Nortel DMS-10)

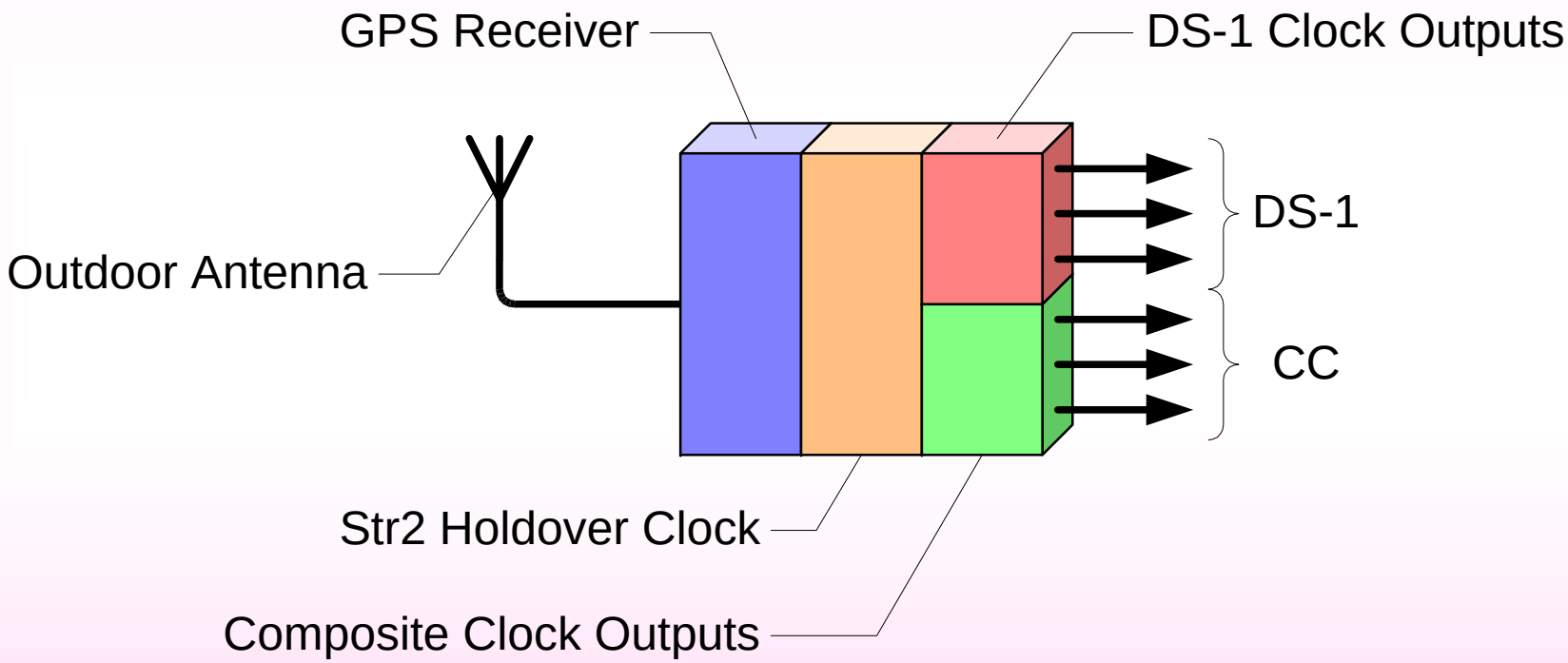
# Synchronization Supply Unit (SSU)

- Previously called Building Integrated Timing Supply (BITS)
- SSU provides sync outputs for all network elements in a given building or CO
- SSU outputs always are connected in a Star Configuration



# GPS/PRS/SSU

- Non-redundant GPS receiver shown



# GPS/PRS/SSU

- Stratum 2 holdover
  - Costs are comparable to Stratum 3E
  - Holdover accuracy is $1 \times 10^{-10}$ per day
  - Limits DS-1 frame slips to no more than 1 slip in 13 days (in theory anyway)
    - Compare to Stratum 3E: No more than 7 slips in 1 day (in theory anyway)

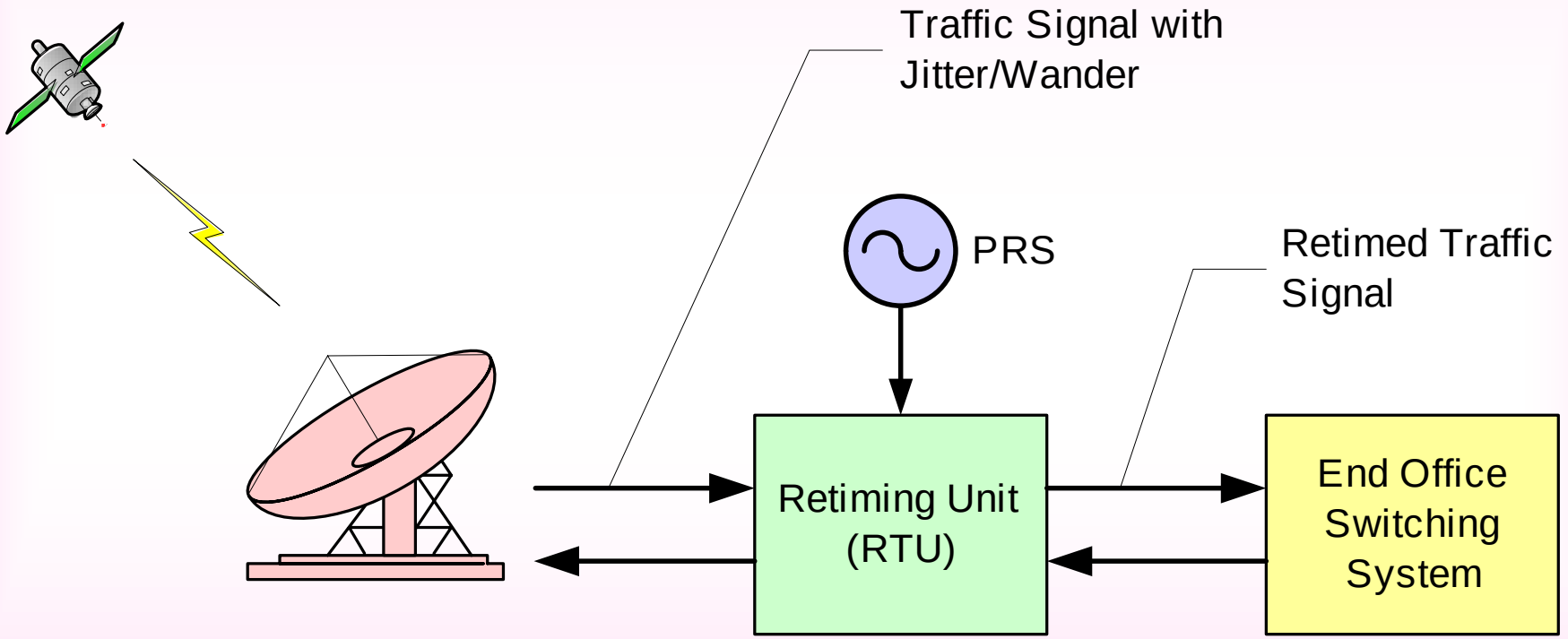
# Timing Inputs

- If a network element has external timing inputs, then it is connected to the SSU
- Not all network elements have external timing inputs, and these implicitly rely on loop-timing
  - Mitel GX5000
  - Siemens DCO
- GX5000 and DCO may be synchronized to a SSU through a “spare” DS-1 digital trunk interface
  - Can be expensive if only a limited number of digital trunk interfaces available
  - Inefficient use of digital trunk interfaces

# Timing System Configurations

- If external synchronization interface is not available
  - Use a retimed traffic-bearing DS-1 interface
    - Requires external Timing Insertion Unit (Retiming Unit) or internal to SSU
      - Called “Pass-Thru Timing”
      - Larus 5620-0 only known external TIU
        - Packaging leaves a lot to be desired in small applications
      - Problems with Datum (Symmetricom) OT-21 when traffic DS-1 uses Robbed Bit Signaling
        - Requires software upgrade to fix
  - Use a “spare” digital trunk interface

# TIU (RTU) Application



# Non-Redundant Equipment

| Manufacturer | Model | Rack Space | Remarks |
|---|---|---|---|
| Datum | OT-21 series | 3.5” | Integral TIU |
| Larus | STS5800 | 3.5” | External TIU |
| Symmetricom | 3500 series | 3.5” | External TIU |
| TrueTime | XL-DC series | 1.75” | External TIU |
| Oscilloquartz | 5240 | 3.5” | Integral TIU |
| Hewlett Packard | 55300A | 3.5” | External TIU |

# Redundant Equipment

| Manufacturer | Model | Rack Space* | Remarks |
|---|---|---|---|
| Datum | TSG3800/PRR10 | 15.75” | External TIU |
| Larus | STS5400 | 12.25” | External TIU |
| Symmetricom | DCD523/LPR | 15.75” | External TIU |
| Oscilloquartz | 5581 | 5.25” | Internal TIU |

* Does not include termination panels

# Configuration – Small Installations

- Redundancy

  < 500 Access Lines — Non-Redundant

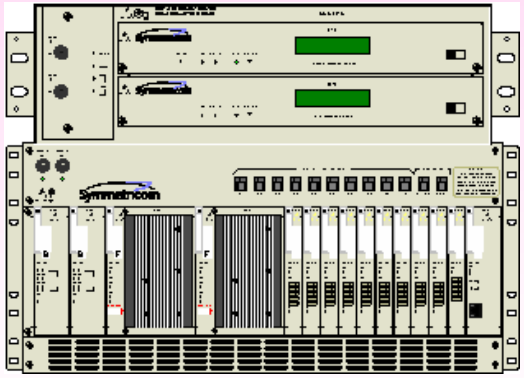
  > 500 Access Lines — Redundant

- PRS based on GPS receiver
- Stratum 2 holdover
- DS-1 and Composite Clock outputs
  - Minimum 2 outputs of each type

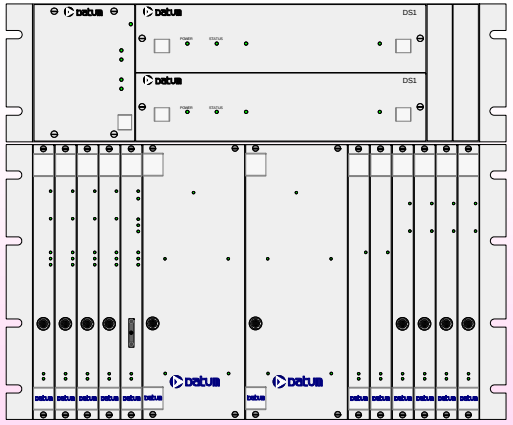
# Costs – Small Installations

- Non-redundant GPS/SSU costs around $10,000 installed
- Redundant GPS/SSU with automatic switching costs around $30,000 installed
- Small companies do not have purchasing power so they pay over twice what larger companies pay for same product
  - Most manufacturers could care less
  - Few manufacturers spend time trying to sell to small companies

# Field Experience



- Symmetricom DCD-523/LPR GPS
  - No problems
- Larus STS5800
  - GPS receiver lock-up problems (and lots of them)
- Larus STS5400
  - GPS receiver lockup problems
- Datum OT-21 series
  - Some field problems (solved by software upgrades)
  - Excellent technical support
- Datum TSG-3800/PRR-10 GPS
  - Some early problems – all resolved okay
- HP 55300A
  - No problems whatsoever



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# Local Troublemakers