



Radio over Fiber Architecture for Metro Access and Backhaul

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Background



A row of four small images: a string of colorful lights, a telecommunications tower, a framed picture of a boat, and a power line tower.

Arasor

Provide consumers with convenient and untethered access to the internet through wireless and optical solutions

More than three year effort behind the present solution

A close-up, slightly blurred image of a white computer keyboard, showing keys like 'P', 'M', 'N', and 'Z'.

Market

Demand Exists from residential and enterprise customers for:

- Data – typically IP
 - Telephony
 - Interactive Audio/Video
 - Video – broadcast (e.g. IPTV)
- Data rates from few 100 Kb/s to few Mb/s

Both Fixed and Mobile

Network Architecture

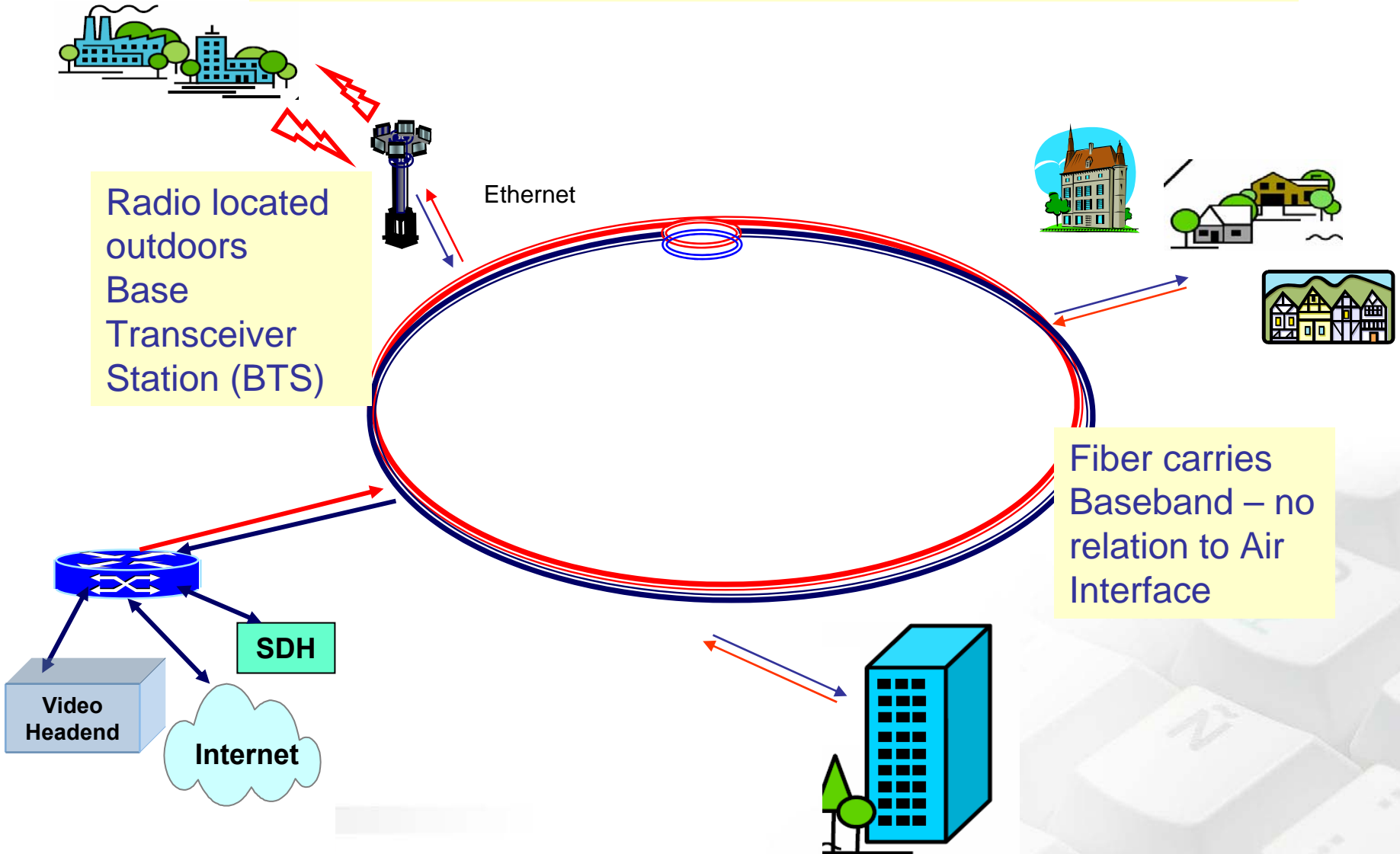
- Fiber rings present in the Metro area
 - Abundant bandwidth
- **Un-tethered** last mile (mobility) => wireless
 - Fiber/Copper to Home – tethered

*Fiber backhaul with wireless access :
network of future!*

Customer Premise Equipment - CPE

- Low cost fixed and mobile CPE's
 - Standard based e.g. 802.16d/e (WiMAX) and legacy
- Triple play – voice, video, data
 - Security
 - Low latency - QoS
- Data rates: Multiple 100 kb/s to several Mb/s per CPE

Traditional Wireless Access + Fiber Backhaul



Desirable Features in a Network

- **Flexible**
 - Ease of upgrades
 - Re-configurable dynamic capacity allocation
- **Versatile**
 - Multiple air interface and backhaul protocols
- **Reliable**
- **Scalable**
 - Low initial investments (“turn on first subscriber”)
 - Ease of expansion

Centralized Architecture?

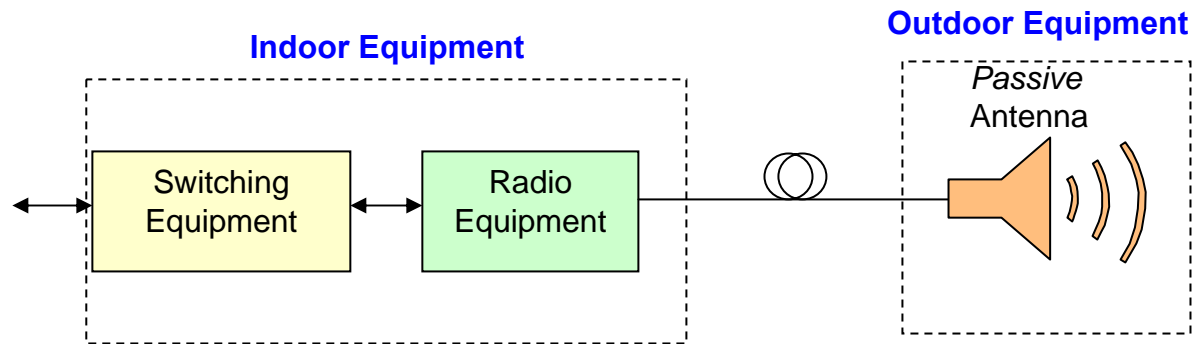
- System Complexity shifted from *Remote* Base Station to a *Central* installation
- System upgrades only at Central Office – future proof
- Simultaneous use of multiple protocols
- OPEX reduction
 - Base station control functionality moved to central office
- CAPEX reduction
 - Lower siting costs (power, space, cooling...)
 - Indoor quality electronics
- Reliability increased due to an indoor environment



Technology



Ideal Centralized Network



Signal through fiber is analog!

Real Centralized Network

- Purely passive antenna can provide a very short range
 - Limitation in power transport through fiber
 - May be acceptable for short-range (indoor) applications
 - Not suitable for metro applications
- Need to utilize DC power and some electronic hardware at the outdoor site
 - Adequate radiated RF power
 - Low noise amplification of weak RF signals

Radio over Fiber Advantages over Traditional Backhaul

- Ease of upgrade. Smooth handover to future technology
- Serviceability OPEX – reduced truck rolls
- Cost analysis CAPEX – less amount of hardened equipment
- Mix and match of protocols
- Synchronization of Data Symbols and RF from a common master clock
- Graceful degradation as opposed to catastrophic failure (sub-carrier based)

Implementation Approaches

- Analog
 - RF
 - IF
- Direct Digitization

Alternative:

Software Defined Radio with Baseband Transport

Implementation Approach - Analog

- In general simpler and more economic than Direct Digitization
- Main issue is impairments due to non-linearity –
 - significant efforts towards impairment mitigation (RS corrects noise due to clipping but not from E/O nonlinearity or DID)
- RF
 - Only amplifiers required at outdoor plant
 - Impairment mitigation difficult
 - Expensive compared to IF
- IF
 - Frequency converters in addition to amplifiers required at outdoor plant
 - Impairment mitigation more realistic

Implementation Approach - Direct Digitization

- Capable of long fiber reach
 - Lower susceptibility to impairments
 - Secondary importance in metro networks
 - Major source of noise is from quantization
- May be unattractive economically
 - Complexity
 - High speed components
- Inefficient in bandwidth
 - More than an order of magnitude increase in data rate
 - » 50 Mb/s over 10 MHz requires needs ~500 Mb/s over fiber
 - Problematic for MIMO implementation

Impairment Mitigation in Fiber

- Crest factor reduction
- Optimum sub-carrier channeling plan
- Electronic pre-distortion
 - Combined pre-distortion of PA and E/O
- Dispersion induced distortion (DID) mitigation by Post-distortion

Use of WiMAX (802.16) for IP transport

- NLOS operation with long range
 - OFDM
 - Spectral efficiency - high level QAM
- Security
- QoS
 - Low latency
 - Multiple SLA's
 - TDMA
- Large (>100) number of simultaneous sessions per carrier
- Upgrade to mobile operation 802.16e
- Beam shaping
 - Optimum coverage
- Space-time coding
 - Interference mitigation
 - Increased throughput

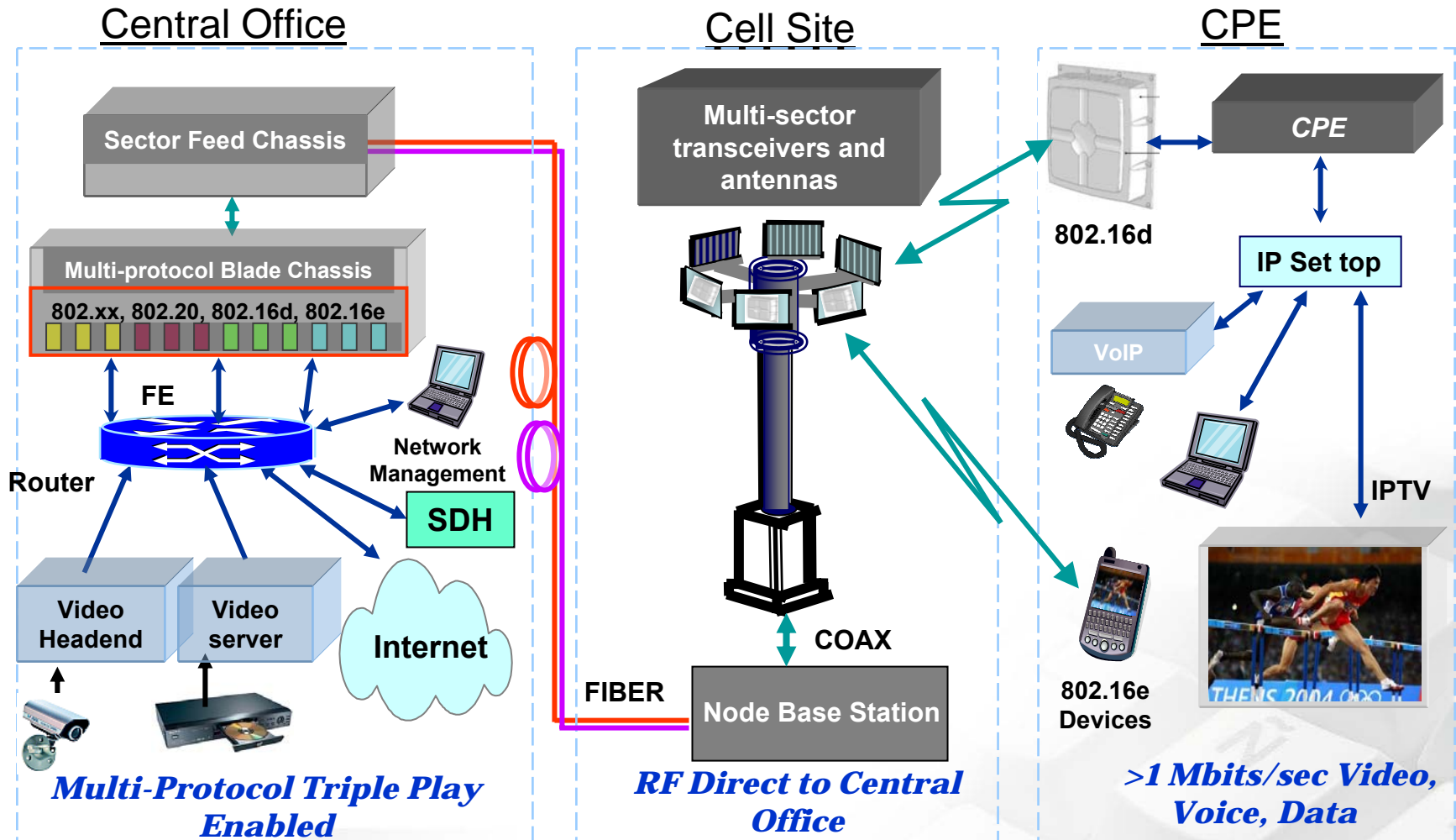


Implementation



Network Architecture

Centralized Access and Backhaul Provides Total WiMAX Solution



ROF Sector Feed Chassis

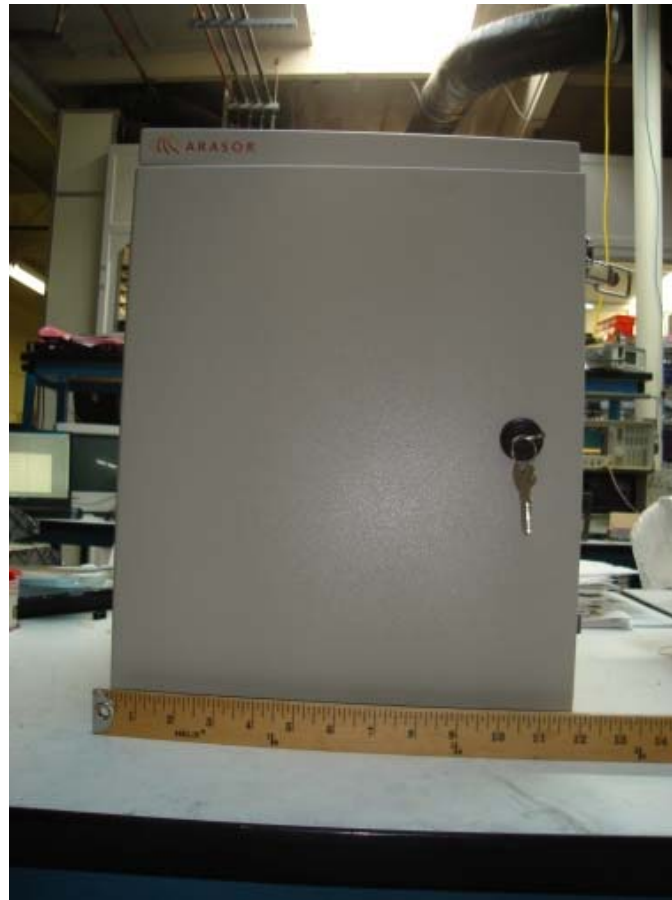


IF Carrier allocated for each sector

E/O and O/E

Base station Node

- O/E and E/O
- Power feed
- Feeding sector transceivers



Transceiver

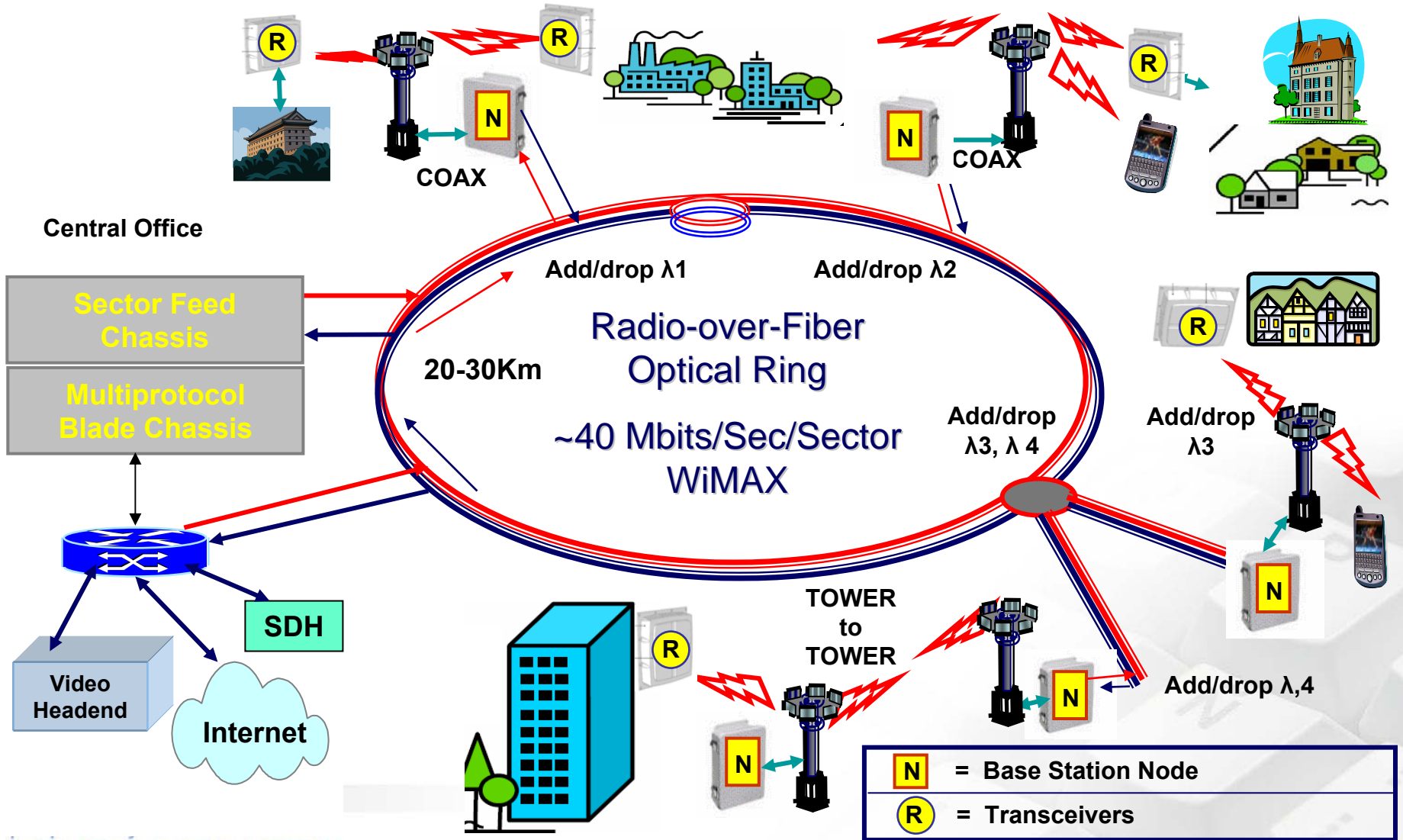
- Up/Down Converter
- PA, LNA etc.



Base station Node with One Sector



Ring and Star WiMAX Network Deployment



Conclusion

- Radio over Fiber first generation offering
- 802.16 – 2004 (WiMAX) based IP transport system
- Multi-carrier IF based optical transport
- TDD and FDD offering in licensed and unlicensed bands
- Field trials ongoing in China and Australia
 - Video streaming
 - Video conferencing
 - Voice over IP



Thank You



Objective for Service Providers

Provide the total and optimum
access + backhaul transport
leveraging on
existing fiber infrastructure