Municipal Broadband: Cases from the United States

Marvin Sirbu

Carnegie Mellon University

Engineering and Public Policy

(Joint work with Sharon Gillett, William Lehr and Carlos Osorio of MIT and Anupam Banerjee of CMU)

* ***Research supported in part by the U.S. National Science Foundation, and MIT CFP industry sponsors***

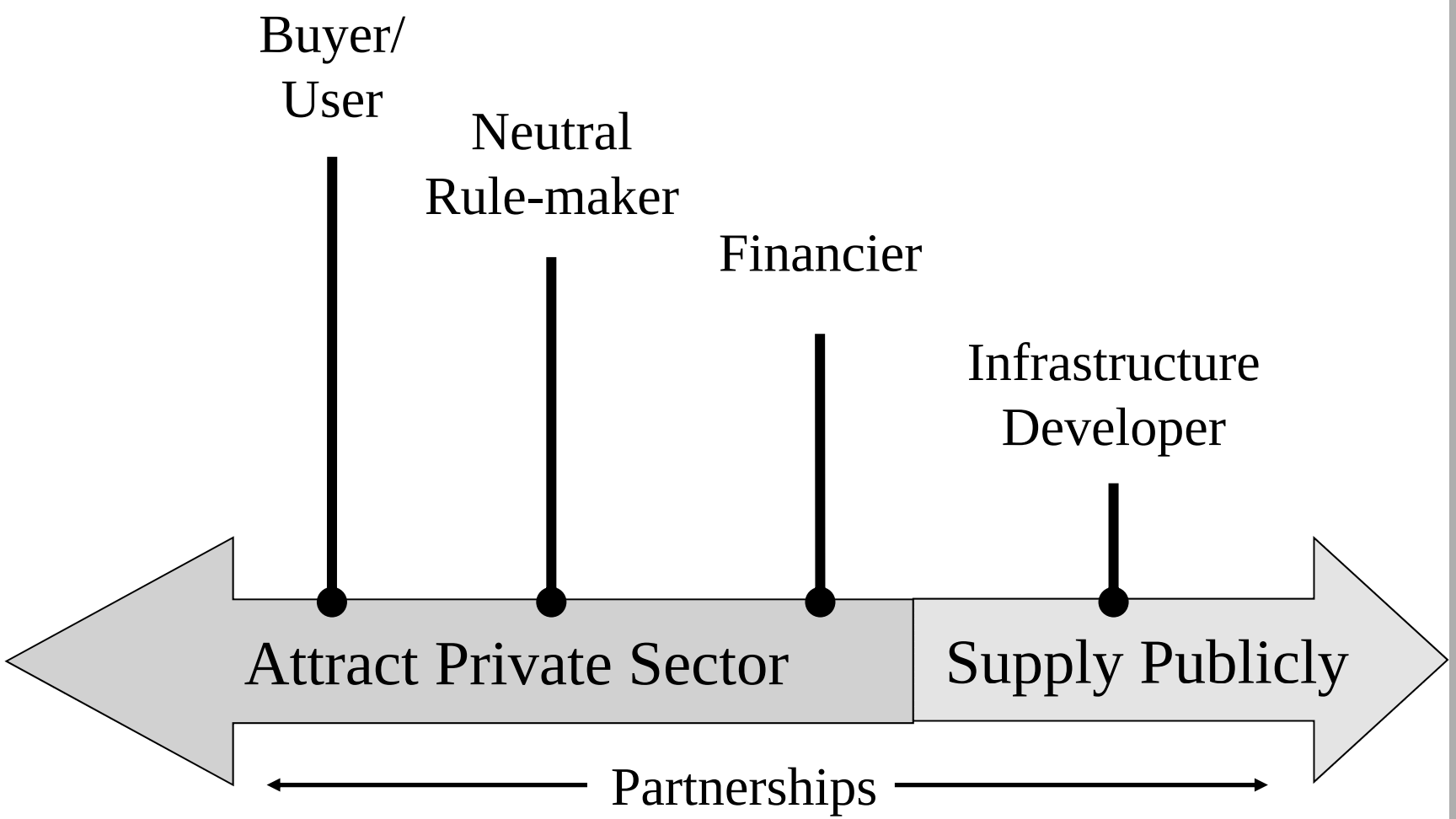
Communities Care About Broadband

- **Broadband is increasingly seen as essential infrastructure for the Information Age**
  - E-Government
  - Economic Development
  - Education
  - Telemedicine
  - Entertainment
- **If Broadband not available—or unaffordable—communities are taking the initiative**

What Communities Can Do To Promote Broadband

- **Buy it for internal use**
- **Aggregate government and private demand to induce private providers into the market**
- **Facilitate entry through access to public infrastructure and ROW**
- **Finance entry by private providers**
- **Directly provide broadband infrastructure**
  - Wholesale only
  - Retail

Taxonomy: Role of Gov't vis a vis Broadband



Source: Gillett, October 2003

Government as Buyer/User

Type of Government Intervention	Examples
Measure Demand	• Demand Assessment (Surveys or online registration)
Stimulate Demand	• "Extension" programs (Training businesses in effective ICT use) • Community technology centers (Training citizens, primarily disadvantaged, in ICT use, e.g. Atlanta); • Sectoral pilots (E-government, distance education, telemedicine etc.) • Community information services (Web pages for local businesses and community groups, e.g. Blacksburg [Virginia] Electronic Village)
Aggregate Demand	• Buying Cooperative (Group pricing) • Anchor Tenant (Government's telecom contract in exchange for broader infrastructure availability, e.g. Chicago CivicNet)

Aggregation usually requires a regional approach

Government as Rule-Maker

Type of Policy	Examples
Access to Local Facilities	• Franchising/Licensing and Rights of Way (Use of streets and other public property) • Utility pole attachment (Rules for adding wires and equipment) • Zoning (Rules for facilities placement, esp. wireless antennas)
Coordinated Planning	• Conduit installation during road construction (e.g. Chicago CivicNet) • Antenna siting (e.g. Dubuque, IA)
Industry-specific Regulation	• Negotiation of cable franchise agreement (Cable system upgrades, deployment of networks for municipal use, schools and libraries, etc.)

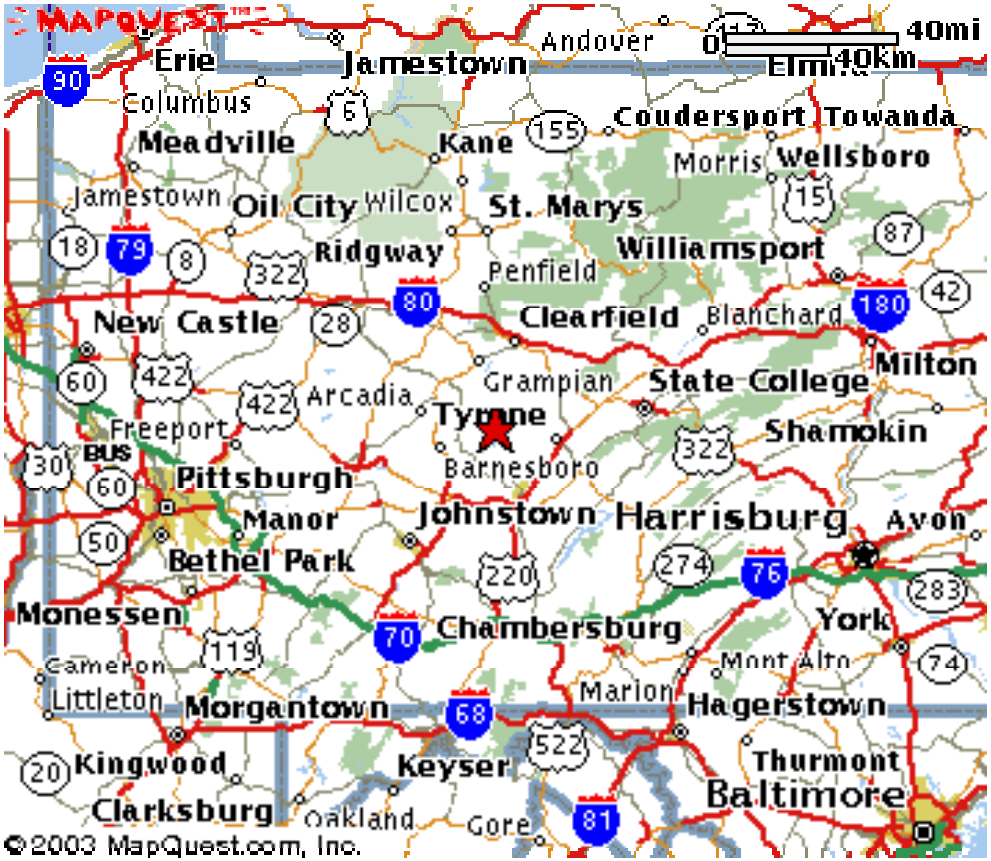
More classic "policy" - at the local level

Government as Financier

Target of Subsidy	Examples
Providers	• Grants • Loans (typically at lower-than-market interest rates) • Tax Incentives
Users	• Equipment • Service (typically for a limited time)
Community Groups	• Planning Grants • Training • Non-profit deployments

Bigger pots at higher layers of government

Glendale School District Flinton, PA



- **$457,000 “digital divide” grant - GAIN**
- **Extend wireless bb Internet access from school to nearby communities, schools**
- **Mobilize community support for “100 laptops” – tech and job skills training**

Federal funds, state administration, local use

Gov't as Infrastructure Developer

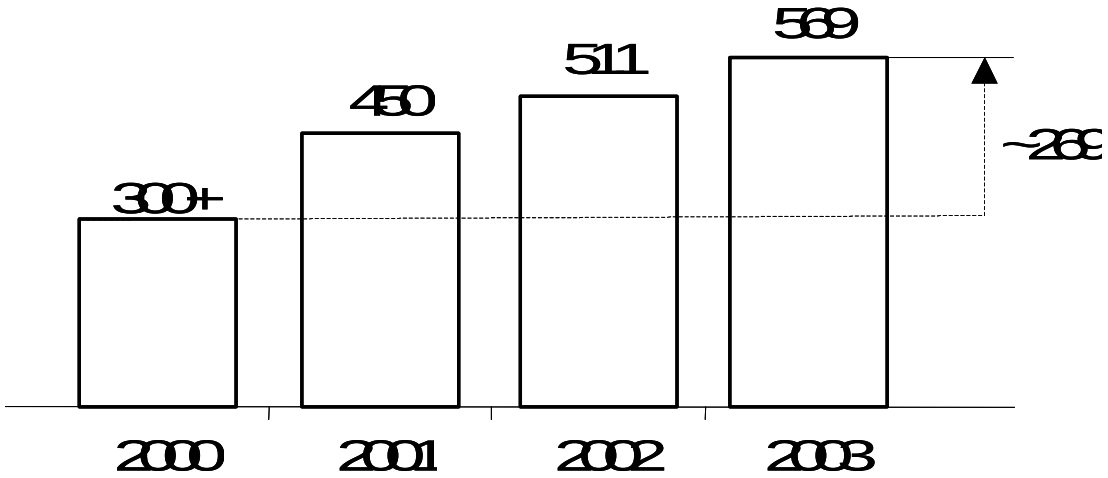
Decision Factor	Options
Targeted Users	• **Government** (including schools, municipal facilities) • **Businesses** • **Residents**
Type of Infrastructure	• **Ducts or conduit** (possibly with dark fiber) • **"First mile" network** (connections to customer premises) • **Interconnection point(s)** (e.g. neutrally administered "carrier hotel") • **"Middle mile" connection** (backhaul links to other locations)
Technology (when applicable)	• **Wireless** (unlicensed or licensed) • **Wired** (copper, hybrid fiber-coax, fiber)
Services	• **Broadband** (Internet access, other data communications) • **Video** (cable TV) • **Voice** (telephony)
Government Responsibility	• **Finance** (bonds: special issue or general obligation) • **Build** (may contract to private sector) • **Operate** (may contract to private sector)
Business Model	• **Wholesale** (local government sells capacity to carriers, or leases dark fiber to anyone but with no associated service, or provides "open access" platform to multiple ISPs) • **Retail** (local government sells higher-level services to end users)

Almost entirely local

Economic Justification for Municipal Entry

- **“Market Failure”: Private alternatives inadequate.**
  - No option or options are inadequate.
  - Social benefits that are not appropriable by private provider (non-economic and economic benefits)
  - Last-mile “bottleneck” persists
    - Monopoly pricing
- **“Opportunistic entry”: Low incremental cost because can take advantage of investments made for other reasons**
  - Internal government use (eGovernment)
  - Schools, Libraries
  - Public Safety
  - Municipal Utility

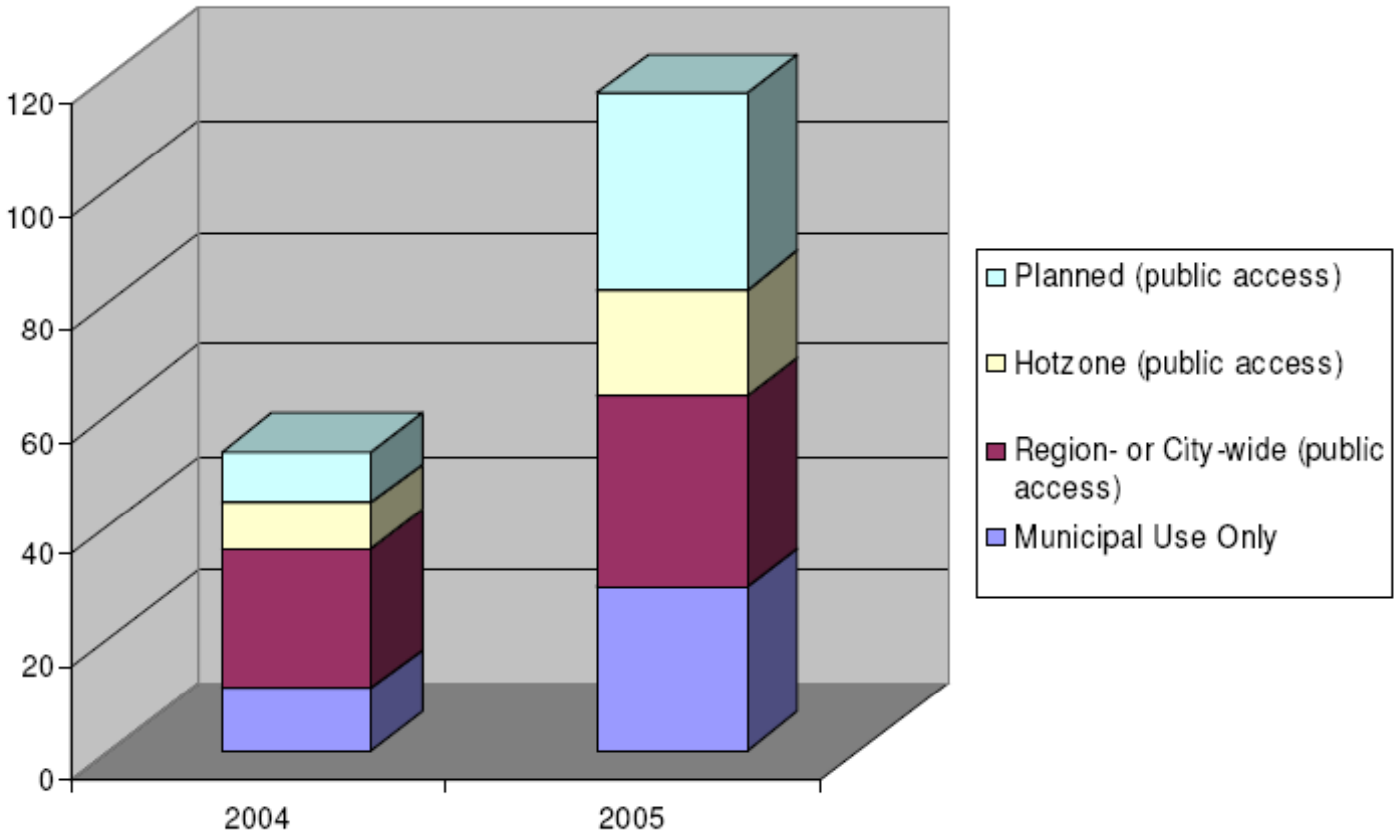
APPA Data: MEUs Offering Communications



- **Internal Services**
  - Utility communications (e.g. AMR, SCADA)
  - Data communications for municipal government
- **External Services**
  - To businesses: dark fiber, leased lines
  - To consumers: mainly CATV [95], ISP (dialup & broadband [62]), & telephony

Source: American Public Power Association (APPA). Analysis conducted on 2002 data.

Municipal Wireless Initiatives in the U.S.



Source: Esme Vos

Open Access Models in Municipal Broadband

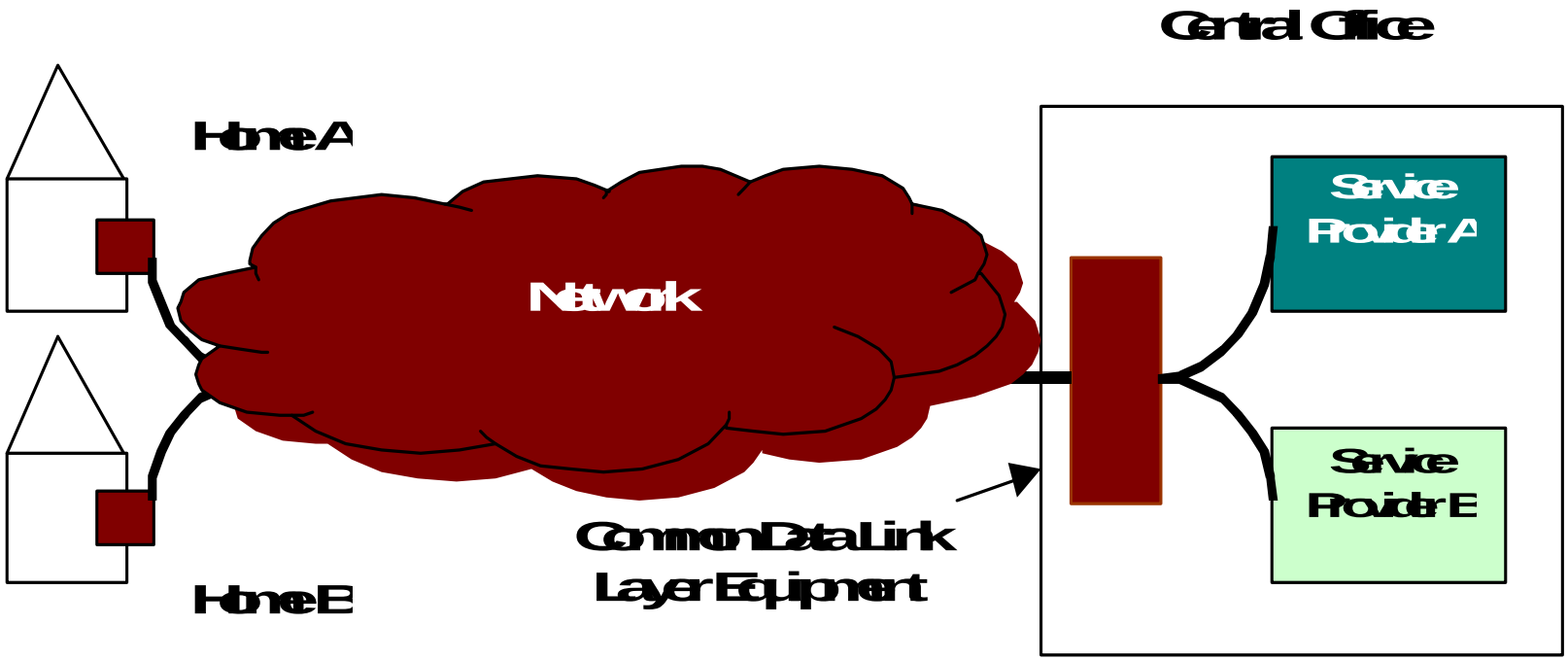
- **What is Open Access?**
  - Multiple competitors use a common shared infrastructure
  - Customers can elect services from alternative suppliers
- **Several states in the U.S. permit municipal provision of broadband only on an open access basis**
- **Open Access principles can be applied to both wireless and FTTP systems**

Open Access and Layering in FTTP

Layer:	**Municipality provides…**
0	Conduit and collocation facilities.
1 (Physical Layer Unbundling)	Dark fiber leasing, or perhaps, Optical Layer unbundling (CWDM or DWDM in PONs)
2 (Data Link Layer Unbundling)	Dark fiber and link-layer electronics at each end. For example, Ethernet-based VLAN, or ATM-based PVCs.
3 (Network Layer Unbundling)	Basic network service provided. For example, IP Layer 3 service over cable using policy-based routing to multiple ISPs

Open Access Models in Municipal Broadband

- **Example of Open Access at Layer 2**



Open Access in Municipal Wireless

- **In San Francisco and Philadelphia, Earthlink will build out a citywide WiFi infrastructure using mesh networking technology**
- **Multiple service providers can purchase wholesale access to the wireless infrastructure to provide retail services**
- **The city can act as its own service provider to deliver service to government agencies**
- **Different service providers may have different business models**
  - In San Francisco, Google will retail a low speed service that is entirely advertising supported
  - Earthlink will provide a higher speed retail service funded by charges to subscribers

Open Access Decision Points

- **To which services?**
  - Voice telephony
  - Data (ISP): Internet access
  - Data (transport): broadband circuits, dark fiber
  - Video: broadcast TV, VoD
- **At what layer?**
- **With what partnership model**
  - Network operator also competes at retail?
  - What control over identity and number of service providers?
  - Who bills customer? Who pays whom on what basis?
  - Wholesale prices negotiated or regulated?

Open Access Decision Points

- **What shared facilities beyond “last-mile” distribution?**
  - Shared middle mile backhaul to tier 1 ISPs
  - Shared ISP peering point (NAP)
  - Shared telephony gateway
  - Shared video head end

Examples: Braintree, Ma

- **Architecture: HFC**
- **Open for**
  - Voice: not offered
  - Data(ISP): closed
  - Data (transport): closed
  - Video: closed

Spencer, Iowa Municipal Utility (SMU)

- **Architecture: HFC**
- **Open for:**
  - Voice: closed
  - Data (ISP): open at network layer
    - No shared backhaul
  - Data (xport): closed until 3/2004; now open
  - Video: closed
- **Partnership model: voluntarily opened to ISPs to gain political support; SMU recently began own retail ISP service**
- **Pricing: SMU bills customer for bandwidth, ISP bills for retail service**

Grant County Zippnet

- **Architecture: FTTH Active Star, IP video**
- **Open for:**
  - Voice: open at layer 2 VLAN
    - Handoff is circuits from shared VoIP gateway
  - Data (ISP): open at layer 2 VLAN
    - Shared middle mile via NOAANet
  - Data (xport): SONET and Ethernet services
  - Video: Open at layer 2 VLAN
    - Shared headend available for video providers
- **Partnership model: wholesale retail split mandated by state law**
- **Pricing: ZippNet posts wholesale prices. Retailer bills customer**

Jackson, TN, E-Plus Network

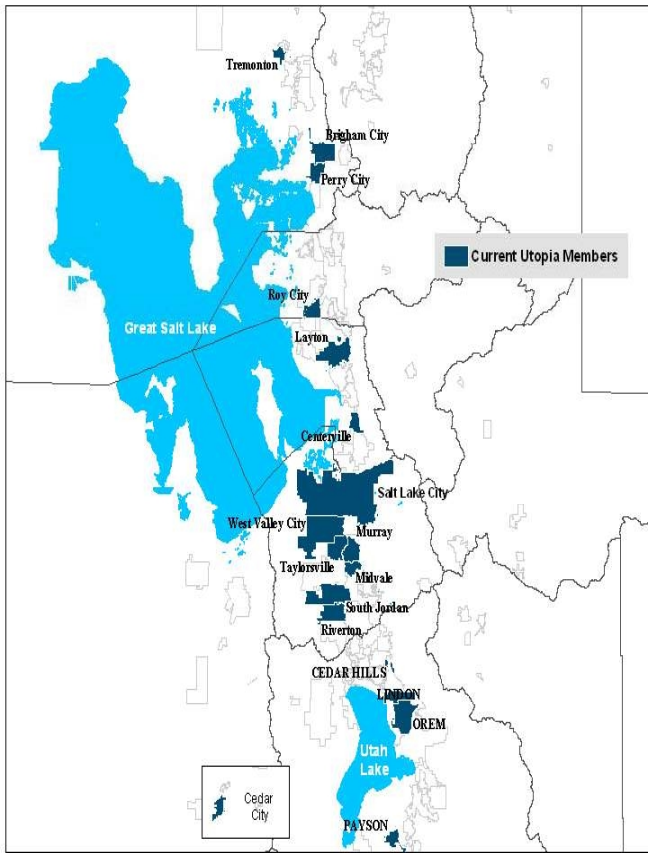
- **Architecture: FTTH Active Star + PON, video overlay λ**
- **Open for:**
  - Voice: open at layer 2
    - Handoff is VoIP packets
  - Data (ISP): open at layer 2
    - No middle mile sharing
  - Data (xport): Ethernet services
  - Video: closed
- **Partnership model: voluntary split to settle a lawsuit**
- **Pricing: negotiated pricing. Charge for wholesale service plus percent of retail revenues. JEA bills customer**

Kutztown Pa Hometown Utilities (HU)

- **Architecture: FTTH ATM PON**
- **Open for:**
  - Voice: open at layer 2
  - Data (ISP): closed
  - Data (xport): closed
  - Video: closed
- **Partnership model: wholesale retail split**
- **Pricing: Negotiated prices**
- **Kutztown would have preferred to be open for data and video but could not find any service providers who would enter the market so decided to offer services itself**

UTOPIA: Utah Telecommunication Open Infrastructure Agency

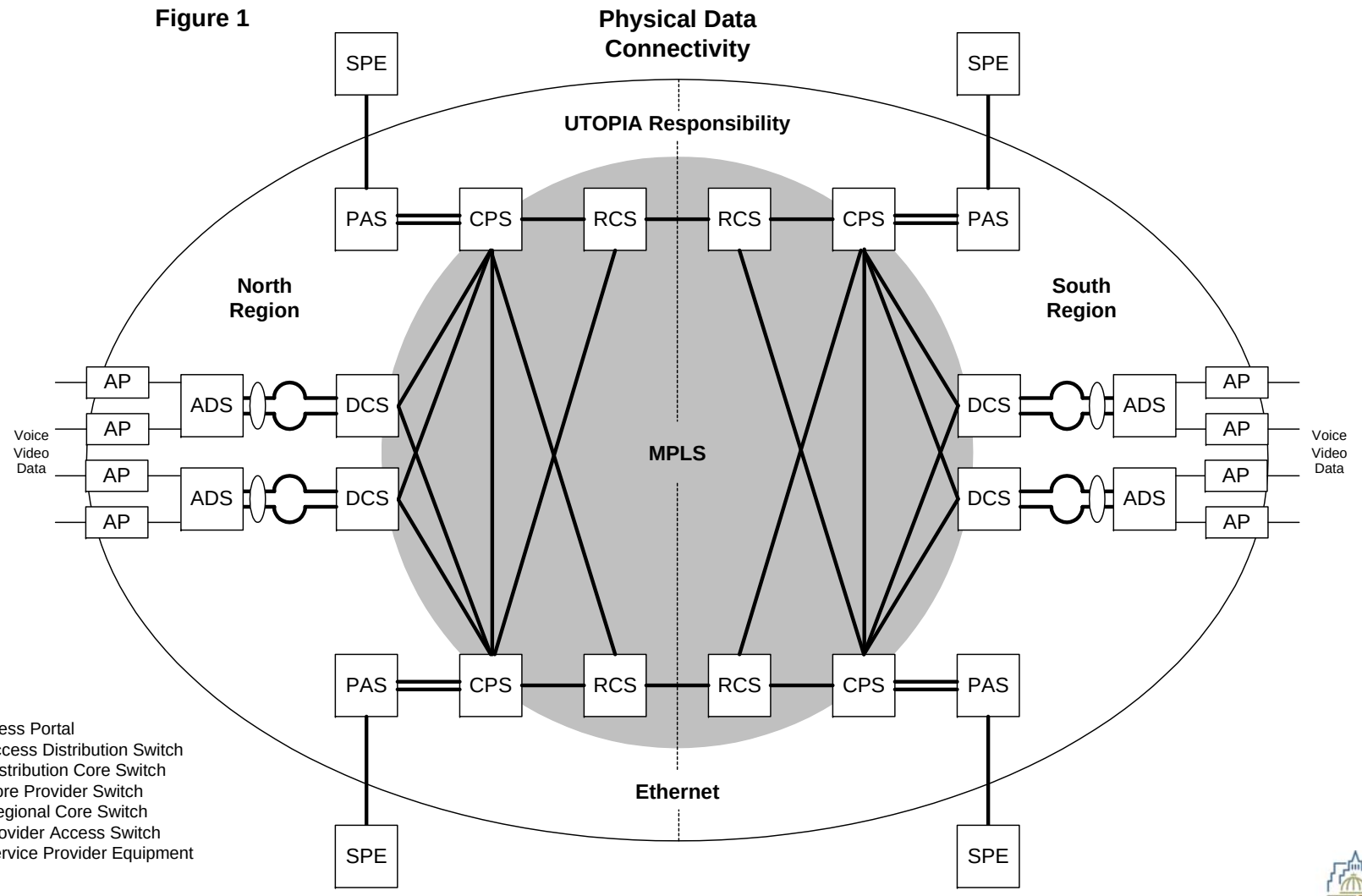
- **18 member interlocal entity**
  - 13 in initial build out
- **Study, finance; design; construct; operate; and, maintain a fiber optic "last mile" network**
- **Wholesale transport of advanced communications services**
- **Active Star FTTP architecture**
- **Largest Open Access project in the U.S.**



Source: Paul Morris, UTOPIA

UTOPIA Network Architecture

Figure 1



AP - Access Portal
ADS - Access Distribution Switch
DCS - Distribution Core Switch
CPS - Core Provider Switch
RCS - Regional Core Switch
PAS - Provider Access Switch
SPE - Service Provider Equipment

DynamicCity

Assessing the Costs and Benefits of Municipal Broadband

- **Traditional Profit and Loss Statement**
- **Broadband creates economic benefits for the community which are not appropriable by the service provider**
  - These benefits may justify municipal entry even when not “profitable” in the conventional sense
  - Compare to provision of subway or bus service in the face of private automobiles and taxis
- **Municipal entry may drive down prices in the local market**
  - E.g. In Kutztown, Pa, local cable incumbent prices 40% lower to Kutztown than to other communities served by the same headend.
  - These benefits are appropriated by consumers who don’t subscribe to the muni offering, not by the muni

Observations: Role of Government

- **Open Access strongly motivated by State policy**
  - Mandatory wholesale retail split in Washington state
  - Onerous burdens in Utah for a muni to offer retail services
- **Voluntary adoption of open access remains rare**

Observations: Legacy Business Models and Service Providers

- **Historically many ISPs did not own underlying physical network**
  - Dialup, DSL

  ➔there were many ISPs willing to be service providers over a muni infrastructure

- **Rise of CLECs in late 90's and VoIP providers more recently created group of companies willing to provide voice service over network they didn't own**

- **Video providers (*e.g.* cable) used to owning the physical network**
  - Few video SPs

- **Result: open access for ISP service found many willing SPs compared to voice or video**

Observations: Technology and Open Access

- **Technology choice and open access policy must be aligned**
  - e.g. Can't provide open access video on a video overlay PON
    - Open access video systems are all using IP video
  - If technology chosen first, it constrains business models
  - If business model chosen first, technologies will be chosen to enable it
- **Impact of Everything-Over-IP**
  - "Sufficient" IP service enables unrelated SPs to provide voice or video over IP—e.g. Vonage, Movielink
    - So if ISP service is open, all services are open
    - Not that simple:
      - QoS
      - Multicast
      - CPE
      - Business relationship

Observations: Beyond the Last Mile

- **In rural areas, the costs of middle mile services may discourage retail entrants**
- **In order to facilitate open access, muni must provide shared services beyond last mile distribution**
  - Backhaul
  - Peering point
  - Video headend

Observations: Open Access and Pricing

- **A wholesale retail split reduces the ability of the infrastructure owner to price discriminate**
- **Cost-based pricing of access favors triple play service providers**
  - High fixed cost requires multiple services to recover cost
  - May limit number of entrants
- **No consensus to date on how to price open access**

Modeling Integrated Services vs Wholesale Retail Split

- **We have modeled a number of different industry structures to analyze the impact of a wholesale retail split on economic performance**
- Vertically Integrated entity **(Network owner provides retail service)**
  - 'Verizon' Model (Profit Maximizing)
  - 'Bristol' Model (Welfare Maximizing)
- Structurally Separated entities **(Network owner, either by regulation or choice, is only a wholesaler. The retail market is assumed to be competitive/contestable)**
  - 'Grant County Profit (GCP)' (Profit Maximizing layer 2 service wholesaler)
  - 'Grant County Welfare (GCW)' (Welfare Maximizing layer 2 service wholesaler)
  - 'Stockholm Profit (SP)' Model (Profit Maximizing dark fiber wholesaler)
  - 'Stockholm Welfare (SW)' Model (Welfare Maximizing dark fiber wholesaler)

What is Service Arbitrage?

- **Verizon/ Bristol can differentiate between data, video and a bundle of video+data and engage in third degree price discrimination.**
- **Grant County Profit/ Welfare *cannot* sell data capability, video capability and video+data bundle capability.**
  - A video bandwidth wholesale service is sufficient to also deliver a video+data bundle. Therefore Grant county cannot set separate prices for wholesale video bandwidth and wholesale "bundle" bandwidth. This is service arbitrage.
- **"Stockholm" can sell only one product at one price: dark fiber access**
- **Therefore a wholesale retail split interferes with the ability of a wholesaler to price discriminate.**
- **Does this inability to price discriminate matter?**

Results of Economic Analysis

- **As expected, welfare maximizers (B, GCW, SW) produce more total welfare than profit maximizers (V GCP, SP)**
  - In a competitive environment, a municipal welfare maximizer generates benefits even for customers of competitors, by forcing competitors to lower prices
- **Little or no difference in profitability of profit maximizing wholesaler, and profit maximizing integrated service providers**
  - Bulk of customers end up taking the triple play, and wholesale can extract as much surplus as integrated service provider in this case

Policy Implications

- **Municipalities or communities that build out FTTP and choose to be wholesalers:**
  - (i) can realize sustainable prices,
  - (ii) are likely to create greater welfare even if they act as profit maximizers (due to innovation spurred by retail competition); and
  - (iii) are just as likely to recover costs (vis-à-vis vertically integrated entities)

Conclusions

- Municipalities are leading the way in experimenting with open access business models
- Open access is becoming easier as more facility-less service providers emerge and technology matures
- The viability of these models in the U.S. remains unproven, though it is still early and there is much experimentation to find the right formula
- Government has played a major role in inducing open access models
- A decision to build an open access system has implications for technology and architecture
- It may be costly or difficult to retrofit open access on a system originally designed to be closed

Conclusions

- **Benefits of municipal networks (whether open or closed) go beyond the lower prices they may charge to customers**
- **As a new competitor, they may force price reductions by incumbents, providing savings even to customers who do not subscribe to the muni system.**
  - E.g. in Kutztown, cable competitor charges $10/month less in Kutztown than in neighboring communities served by the same headend
- **Cross subsidization by cable operators or local exchange carriers in communities with municipal competition poses threat to viability of muni operations**
  - Unlike DBS, muni systems cannot dry up the cross subsidy by competing across the incumbant's territory

For Further Information