# The Future of Mobile Communications

# An Open Access Wireless Market

*Supporting Public Safety, Universal Service, and Competition*

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# Summary

- The cellular market is extremely inefficient, with a small number of carriers dictating supply and pricing.
- Implementing an Open Access Wireless Market (OAWM) will allow supply and demand to determine prices by time and location, with the following consequences:
  - It will Increase innovation, generate new use cases, and diversify traffic patterns
  - It will eliminate the barriers to entry
- This will transform the industry by increasing network utilization, reducing the price of data per GB and increasing data consumption dramatically.
- Rivada is actively working on implementation opportunities globally.

# From monopoly to vibrant competition

**Monopoly**

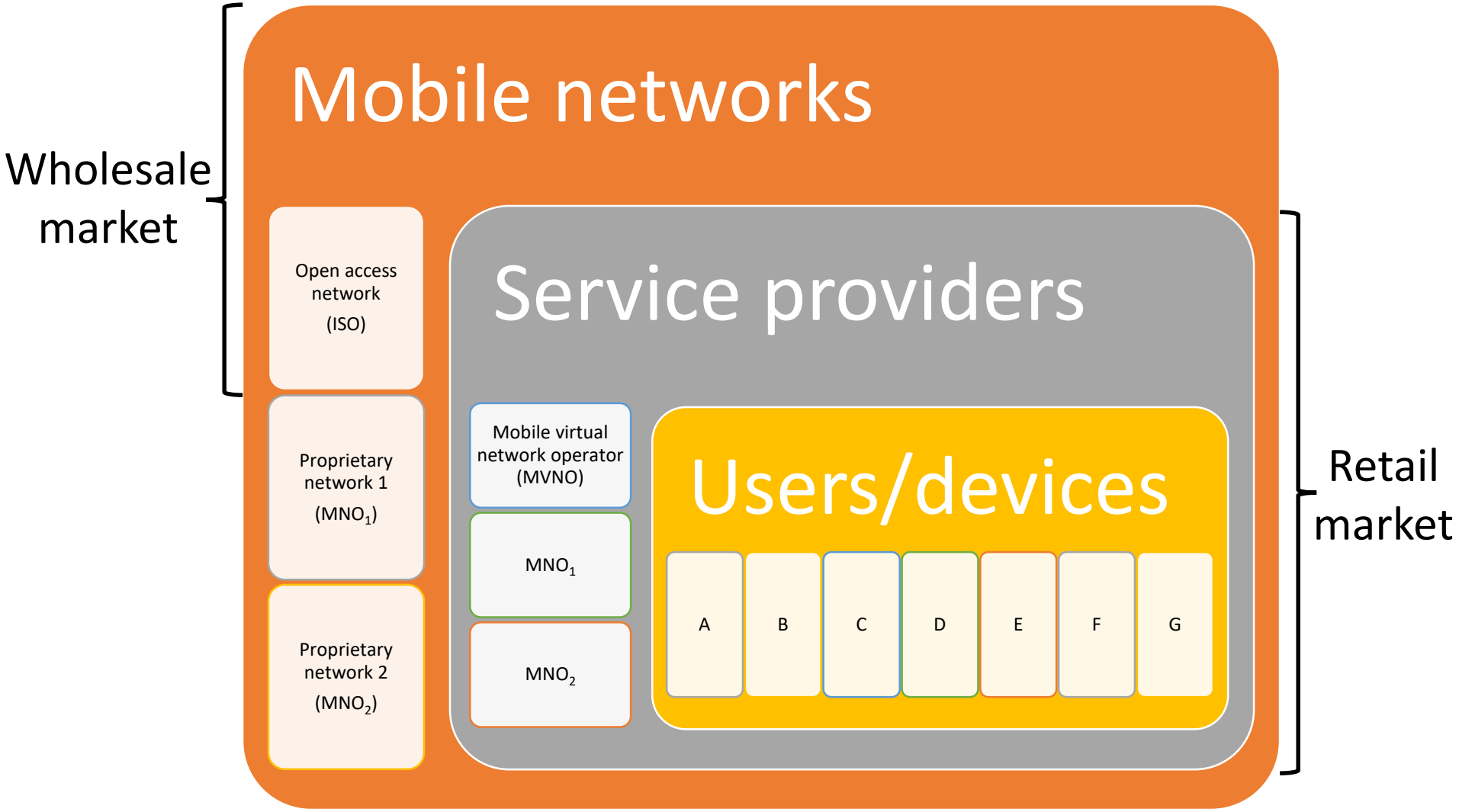
- Original “Ma Bell” telecommunications

**Oligopoly**

- Spectrum auctions
- Mobile communications

**Competition**

- Open Access Wireless Market (OAWM)
  - Wholesale-only provider eliminates the conflict of interest in the carrier retail / wholesale market
  - Neutral network with transparent, non-discriminatory pricing to MVNOs and wholesale consumer
  - Time and location pricing enhances network efficiency and promotes low-cost entry




*Same market model as electricity successfully operating for two decades*

# The Mobile market today is highly concentrated & retail centric

## Spectrum

**Licensed Spectrum**

## Network Operators

**Vertical Integration**

Spectrum Network

Wholesale

Retail

## Retail Market

$213 B

$189 B

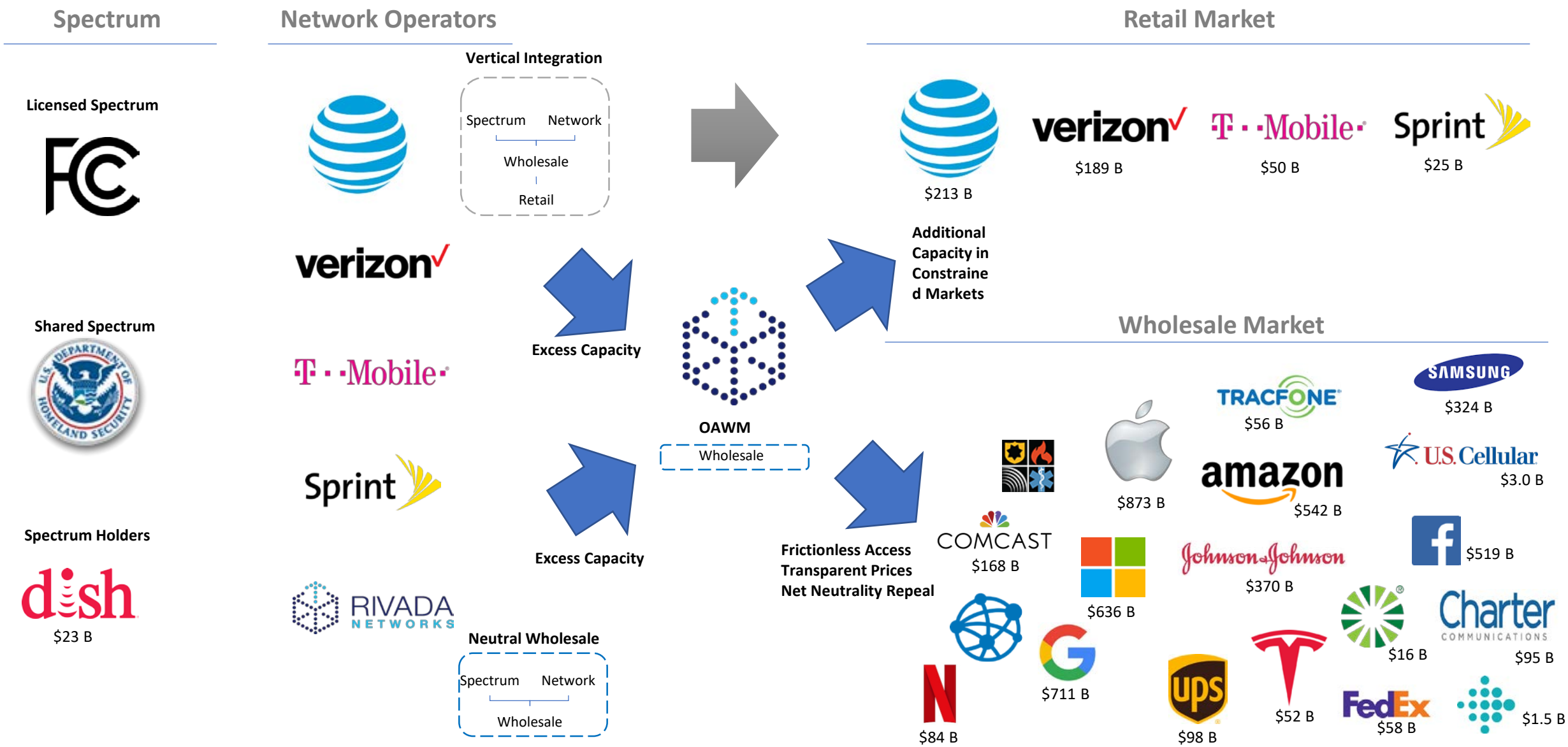
$50 B

$25 B

## Wholesale Market

$56 B

# Mobile market tomorrow will be more diversified



# MVNO & wholesale evolving

## Wholesale

- Wholesale-only provider eliminates the conflict of interest in the carrier retail / wholesale market

## Neutral

- Neutral network with transparent, non-discriminatory pricing to MVNOs and wholesale consumers

## Time and Location pricing

- Time and location pricing enhances network efficiency and promotes entry

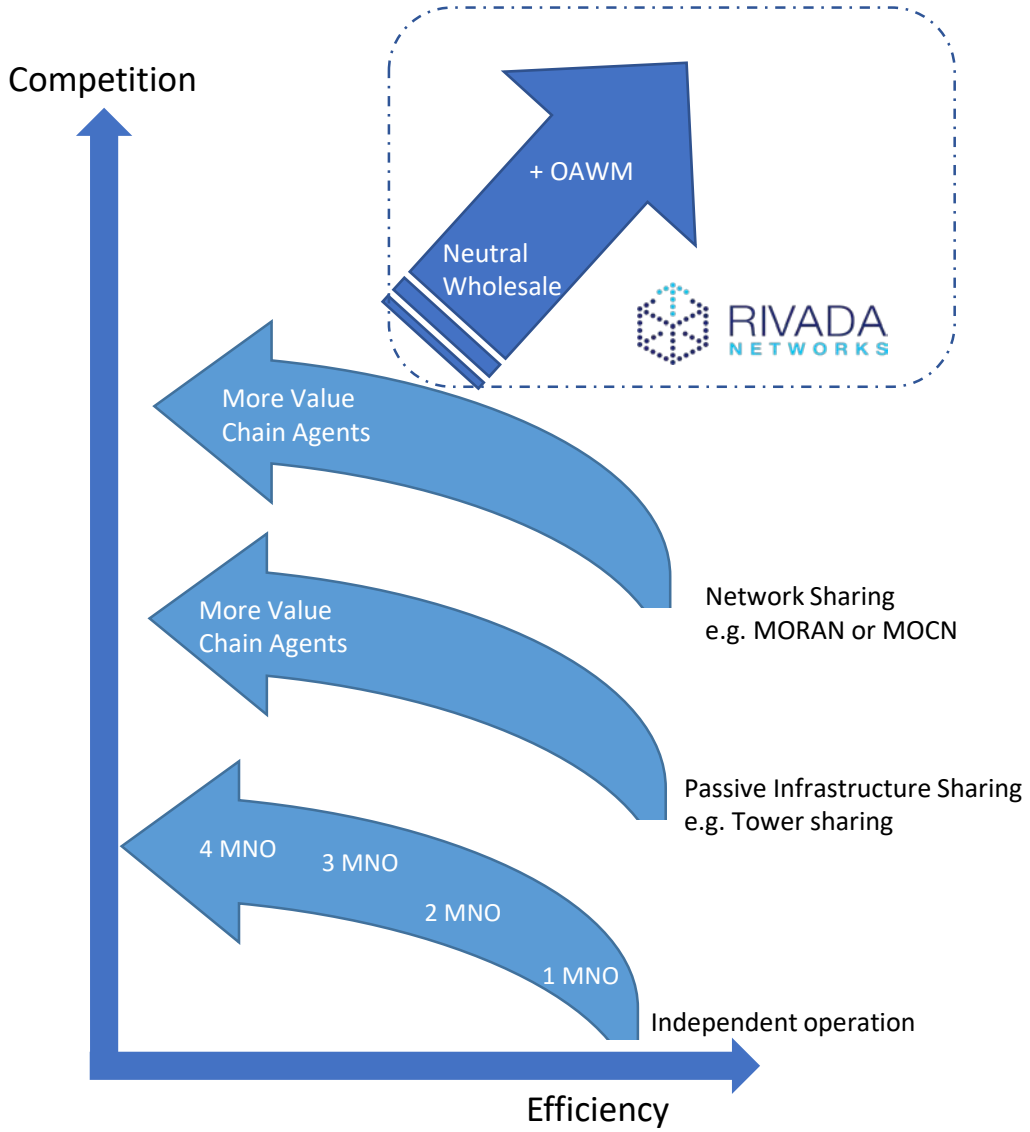
# Range of potential customers is wide & varied

| | | | |
|---|---|---|---|
| ***Wholesale*** | ***Traditional MVNOs*** | — Virgin Mobile<br>— Credo<br>— Ting | — ACN<br>— Ready Mobile<br>— TracFone |
| | ***Cable Operators/Rural Carriers*** | — Comcast<br>— Cox<br>— Charter<br>— iWireless | — SouthernLinc<br>— C-Spire<br>— Cellular One<br>— US Cellular |
| | ***Tech Companies / Innovators*** | — Google<br>— Apple<br>— FreedomPop<br>— Republic<br>— Dell | — Amazon<br>— Netflix<br>— IBM<br>— Hewlett-Packard<br>— Microsoft |
| | ***LifeLine*** | — TracFone<br>— Q Link<br>— Total Call<br>— Boomerang<br>— Budget PrePay | — iWireless<br>— Safelink<br>— TruConnect<br>— Tag Mobile<br>— Ready Wireless |
| | ***International MNOs*** | — Deutsche Telekom<br>— Vodafone<br>— Telefonica | — China Mobile<br>— Orange<br>— KDDI |
| ***Existing MNO's*** | ***Domestic MNOs*** | — T-Mobile<br>— Sprint<br>— Verizon | — AT&T<br>— Regional Carriers<br>— Rural Carriers |
| ***M2M*** | ***M2M Adopters*** | — Aeris<br>— Kore/Wyless<br>— Numerex<br>— Spireon<br>— Geotab<br>— UPS | — Fitbit<br>— UBI<br>— Zubie<br>— Auto OEMs<br>— Gemalto<br>— Trimble |

**There are many interested parties and more to come**

- Diversifying the wireless ecosystem
- Innovating business models
- Diversifying the traffic patterns

# Neutral wholesale network reduces the tension between competition and efficiency




**National Needs**

Universal Service
Competition
Public Safety
Data explosion

**Right Conditions**

Global Standards
Technological Flexibility
Demand Heterogeneity
Scarcity

\+

RIVADA NETWORKS

**Policy Innovations**

Spectrum Access
Infrastructure Access
No Influence
ISO

**Business Innovations**

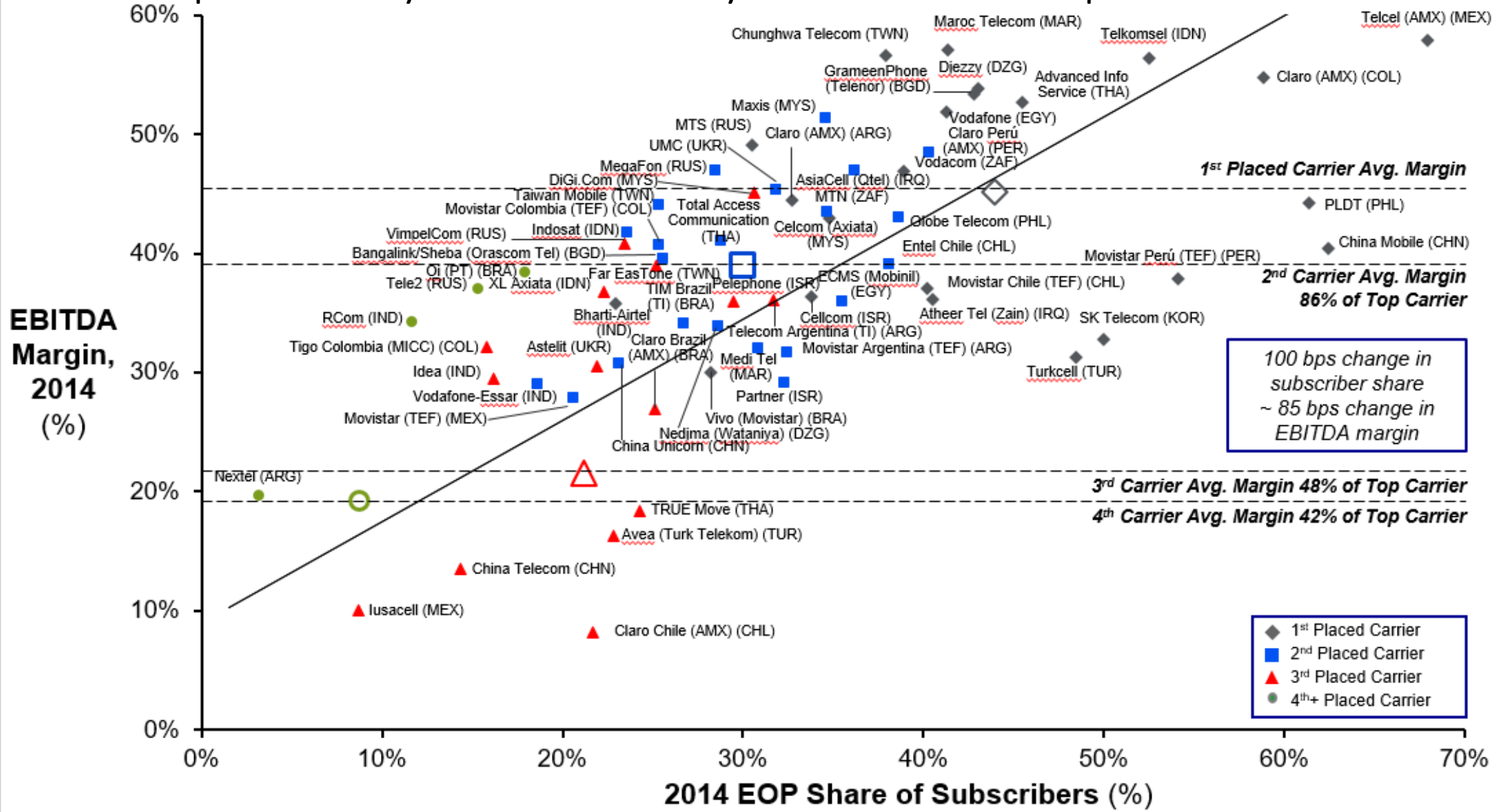
Neutral Wholesale

Time and Location Pricing

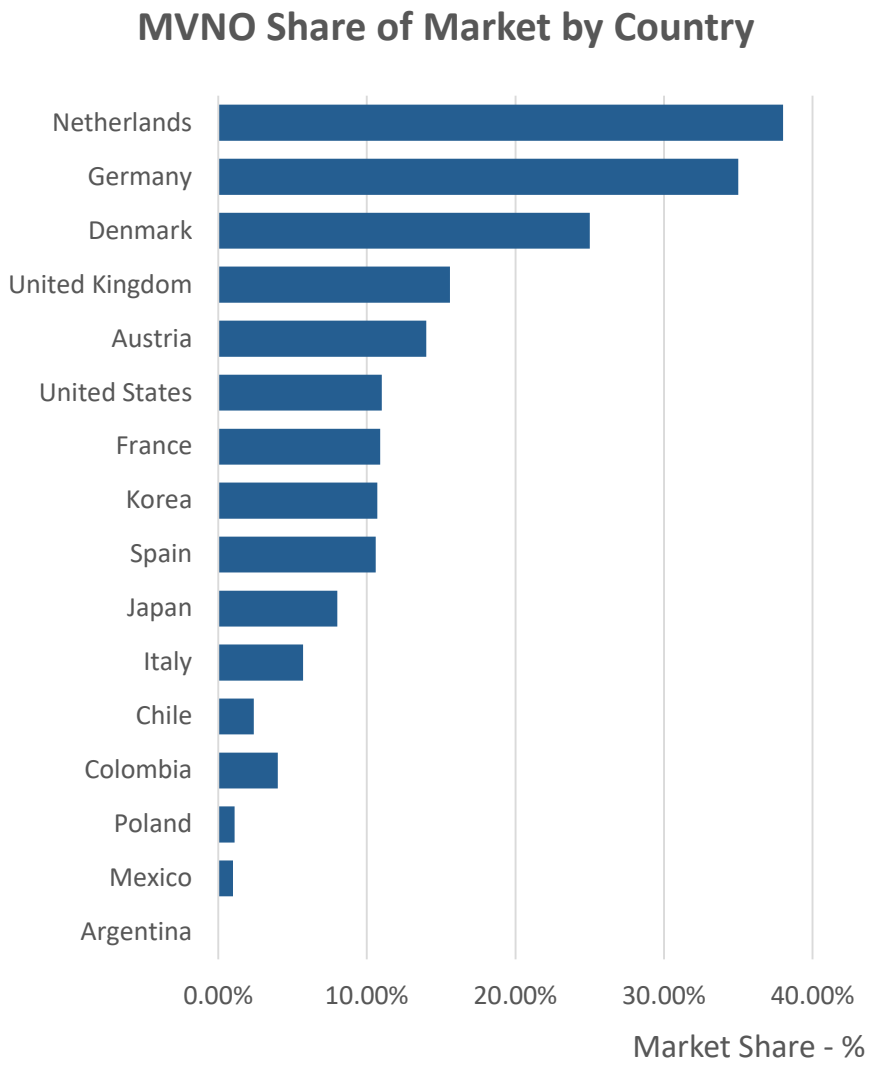
=

**The FUTURE**

# Demand aggregation allows neutral host to enjoy economies of scale previously available only to dominant operators



# Wholesale market represents less than 10% of entire global market

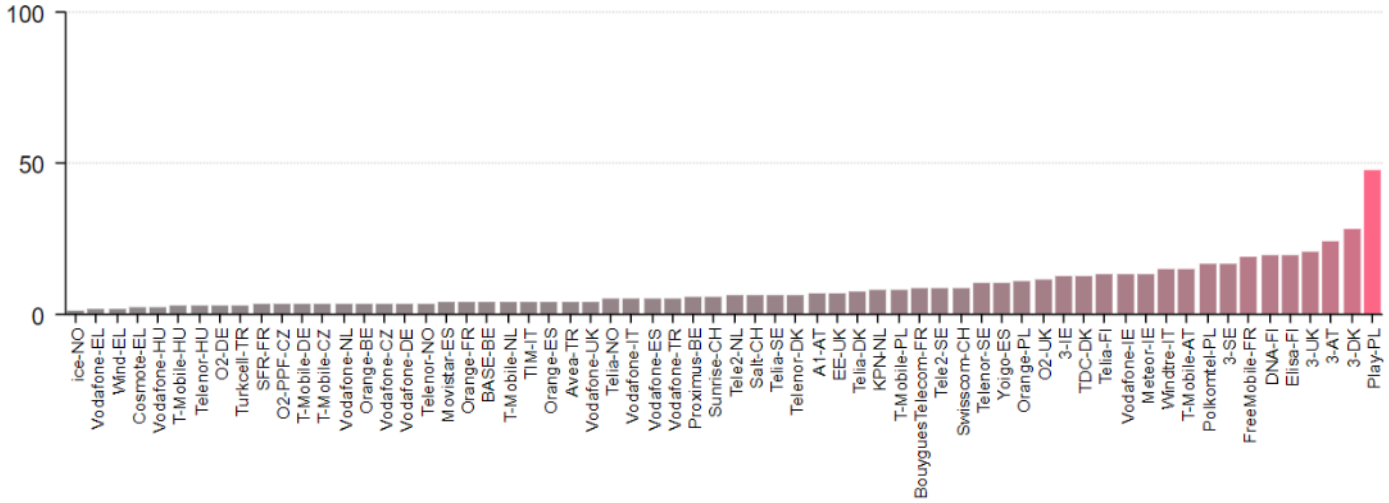



## The Current Model

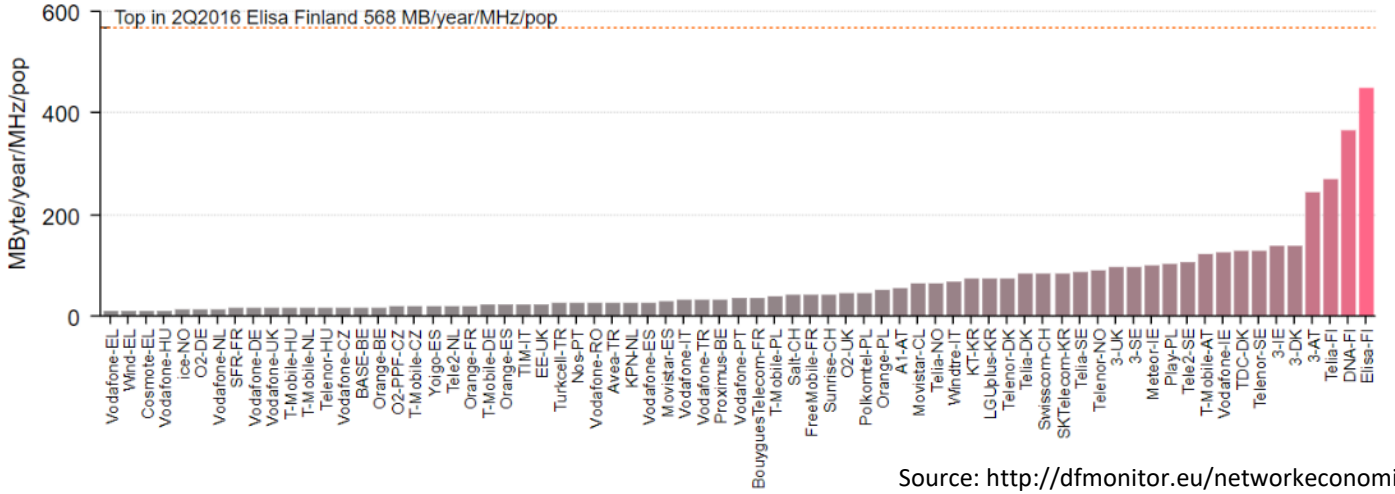
- Inherent conflict of interest between seller (carrier) and buyer (MVNO)
- Buyers are competing with their own suppliers
- This hinders competition and keeps MVNOs small

# Operators are traditionally poor at maximizing value of assets

Network Utilization in 2016




Spectrum Usage in 2016

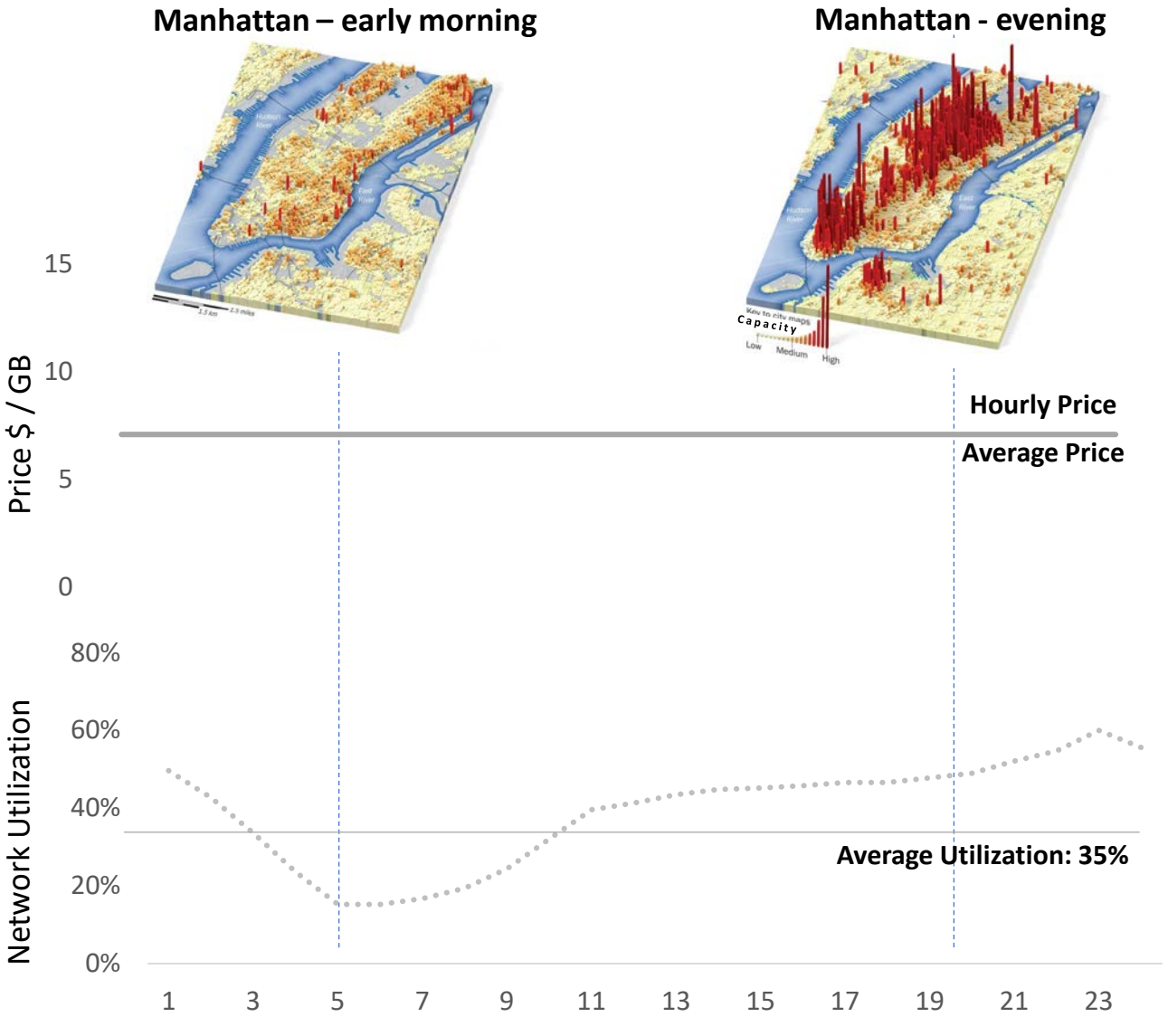



Source: http://dfmonitor.eu/networkeconomics/

## The Current Model

- Networks are built to meet peak demand
- Network utilization is low
- Spectrum utilization is low
- Investment diminished

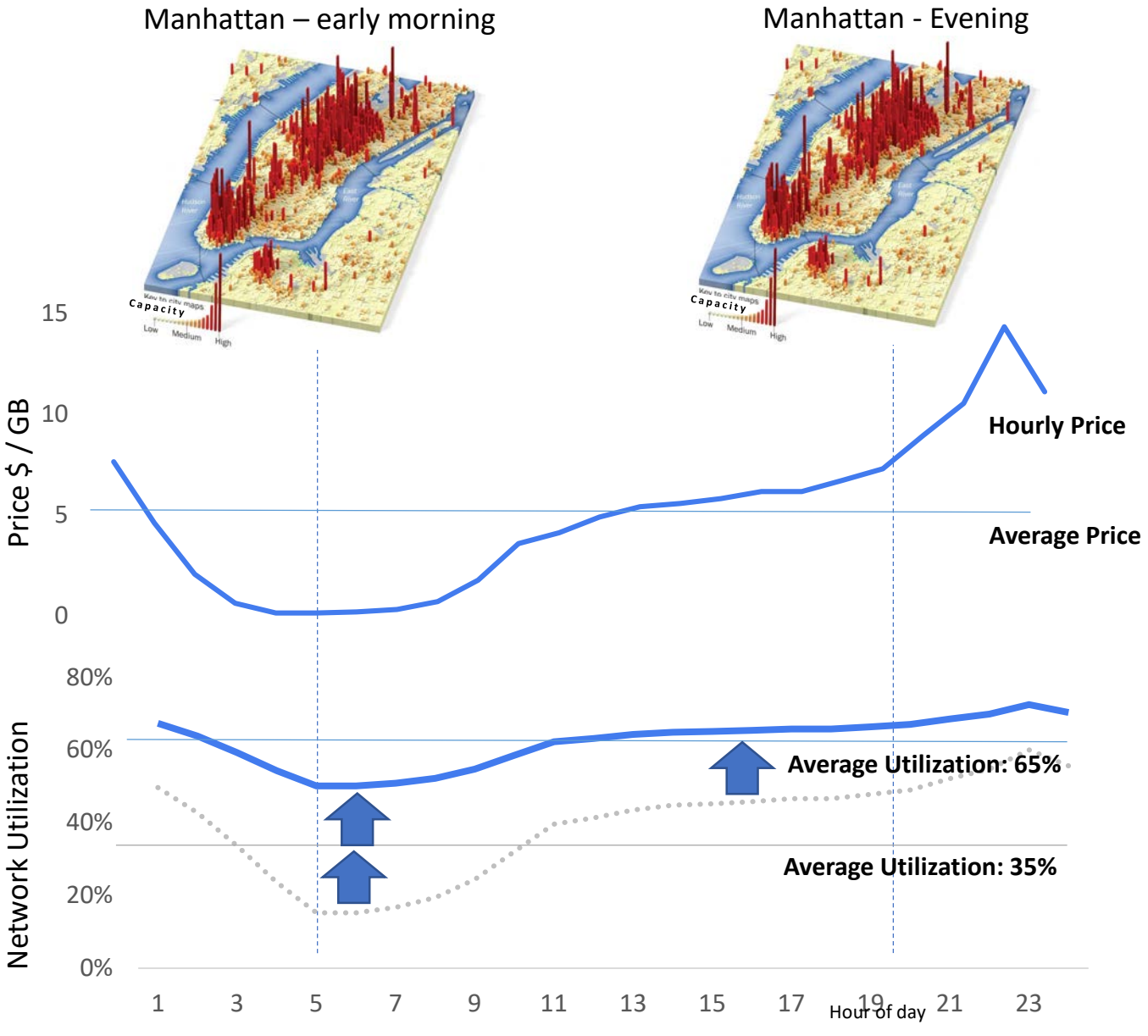
# Operators charge same price despite huge swings in demand




## The Current Model

- There is a big mismatch between data needs and pricing
- Data needs and value vary by time and location
- Data prices are constant

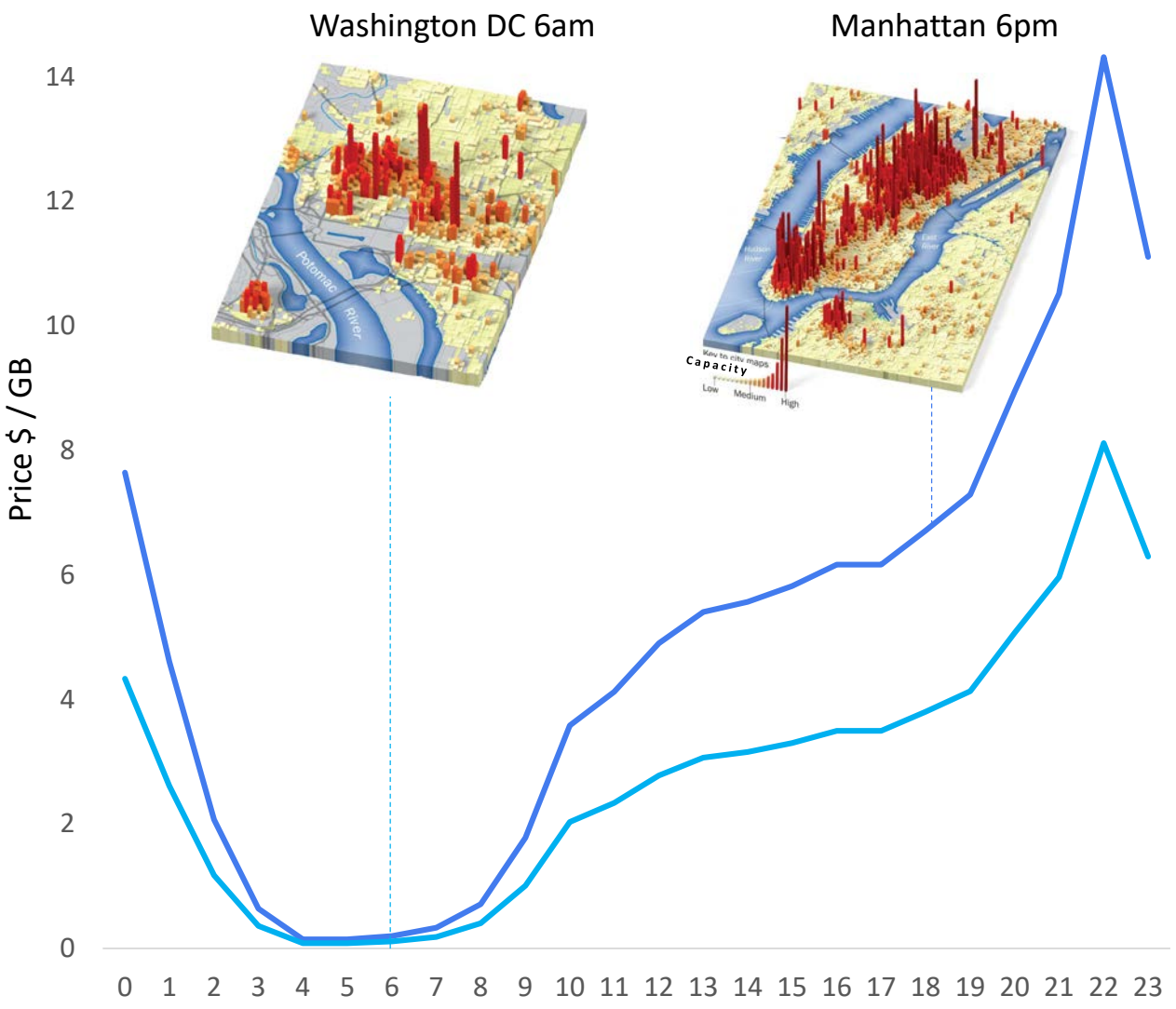
# Applying open access has dramatic impact on asset usage and revenue




## The open access model

- A neutral time and location based market will drive increased utilization
- Prices reflect the value of data at every time and location
- Average prices decrease significantly
- Average utilization increases due to low prices

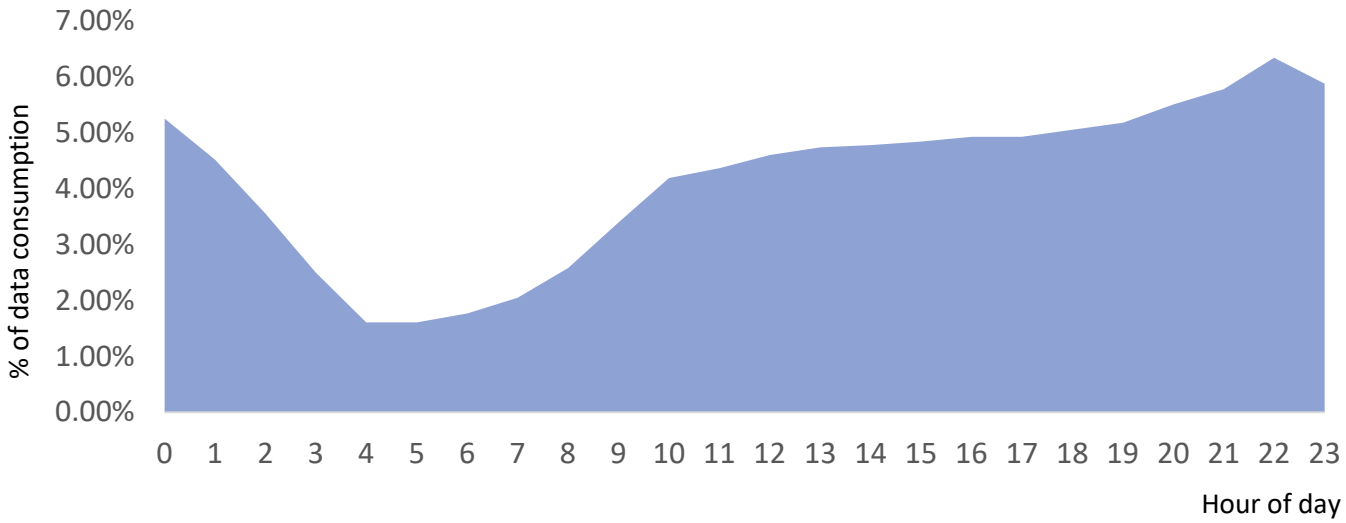
# Location, location, location

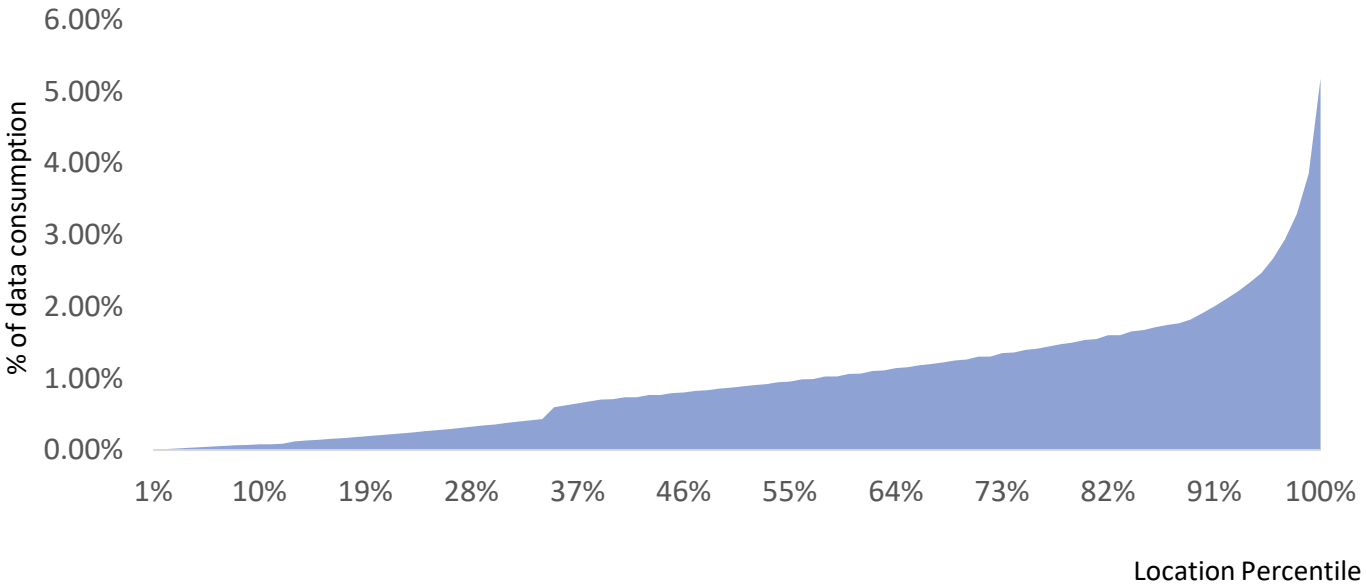



## The open access model

- Prices reflect the value of data at every time and location
- Local Prices reflect local data needs
- Utilization increases everywhere

# Operator traffic patterns



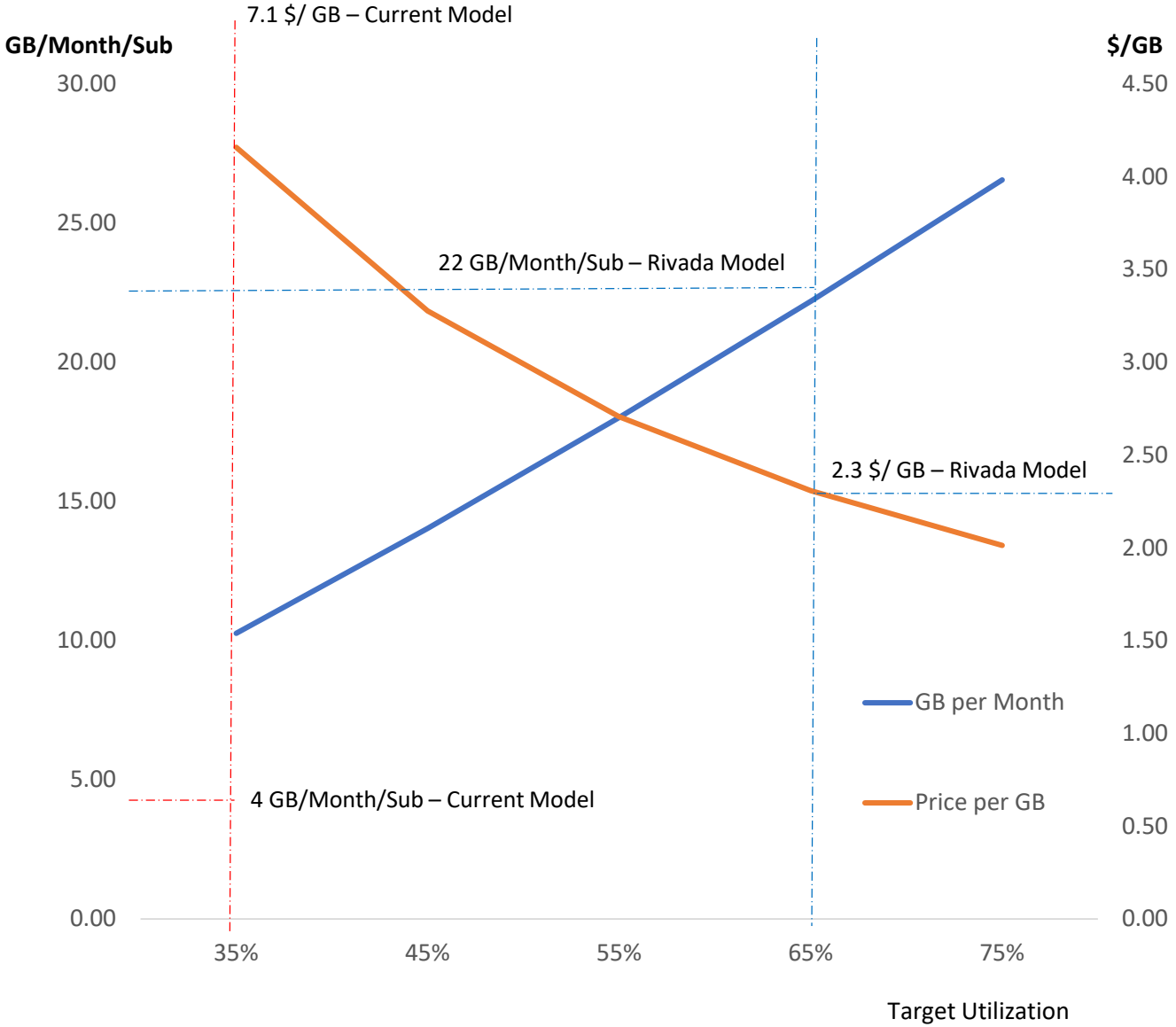




## Anonymized data consumption on a national carrier network

- Data consumption by hour of day
- The network is better utilized in the evening (Netflix Effect) but a lot of capacity is wasted in the early morning.

- The network is broken down into 100 buckets, each with an equal number of sites ordered by usage. The usage in the busiest bucket is 1,700 times greater than the least used bucket.
- Data consumption is highly concentrated in a few buckets, producing low utilization in many areas without much traffic

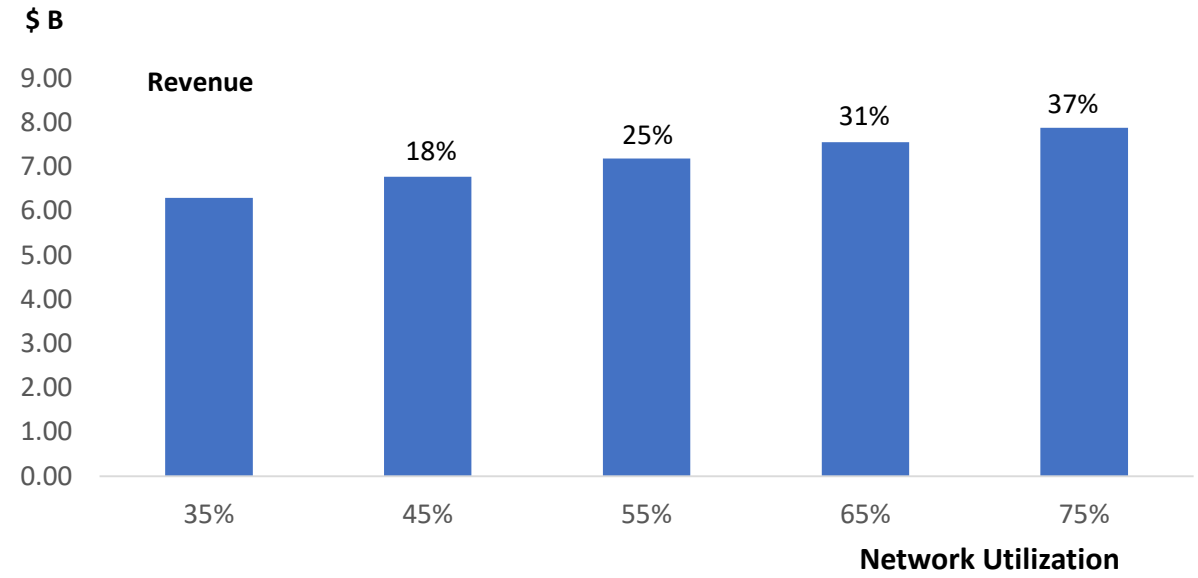
# Open access will have a dramatic effect on date use and price

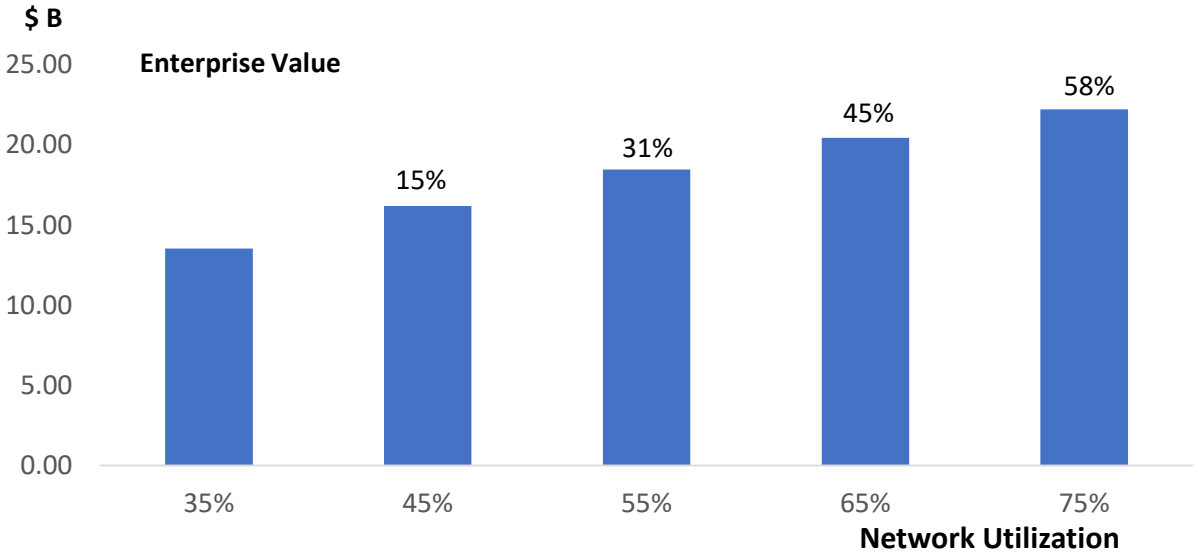



## The open access model

- Coverage Design for a National Network on the 700 MHz band
- Current Model:
  - Price per GB will drop from $7.1 to $2.3
  - Consumption will rise from 4 GB to 22 GB
- Key economic assumptions:
  - Price elasticity: 1.3
  - Elasticity of substitution: 0.3

# An increase in network utilization has a material impact on revenue & enterprise value




## The Rivada Model

- Better utilization means more revenue
  - Existing assets are utilized better
  - New investments have better returns
- When compared with a traditional retail-centric network, the Neutral Wholesale Model with the OAWM can increase revenue and enterprise value
- Increasing utilization from 35% to 65%, increases:
  - Revenue by 31%
  - Enterprise value by 45%

# Characteristics of open access

- Market for wireless **capacity,** not spectrum
  - Capacity (throughput) is generated from both spectrum and network assets
  - Based on best practices from existing time and locational markets. Core tenets are efficiency, transparency, simplicity and fairness
  - All users have access to the same technology
- Feasible for large quantities of spectrum across frequency bands
- Compatible with traditional bilateral wholesale contracts
- Simple to manage:
  - Interference is managed at the network level
  - Transparent, market-driven pricing aligns incentives
- See whitepaper at: OpenAccessWireless.com

## Spectrum Sharing

- Feasible only for marginal quantities of spectrum
- Vertical sharing between drastically different uses
  - Military vs Commercial
  - Mobile communications vs Point-to-Point
- Horizontal sharing between similar users
  - Redundant and idle investments
- Extremely difficult to manage
  - Interference
  - Incentives

# Open access facilitates a more efficient way of allocating spectrum

- Spectrum is paid recurrently:
  - Price reflects the fair market value value of using the spectrum
  - Innovations get accounted in the price

- Nominal barriers to entry:
  - Local and fast deployment is possible
  - Innovation flourishes – new uses of data
  - Competitive prices

## Current license model

Licenses are auctioned to the highest bidder

- Bids reflect the value of:
  - Using the spectrum
  - Rents from monopolistic competition
  - Rents from blocking entry
- Consumer prices ($/GB) are high
- Inferior services
  - Slow deployment
  - Constrained coverage
- Barriers to entry are high
  - Few service providers
  - Few users
- Incentivizes spectrum hoarding

# Open access is a perfect merger remedy

- Set aside a portion of capacity to the open access market
  - Assignment and prices determined to maximize gains from trade in open competitive process
  - Assignment and prices respond to changing market
  - Market evolves with environment
  - Merged entity receives competitive market value for network resource, and ongoing interest in success of service providers

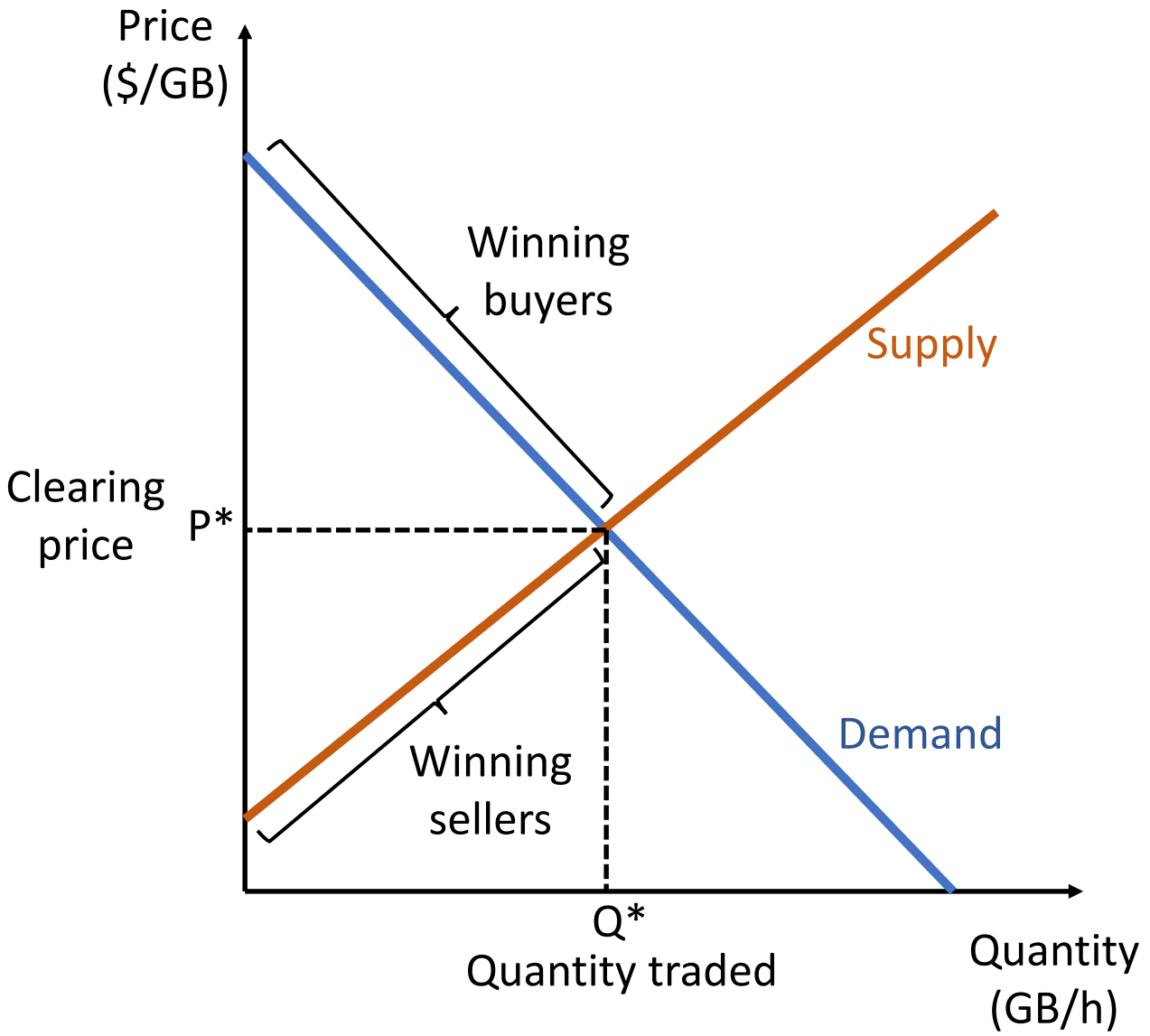
**Based on experience:**

- Similar to recent 4-to-3 merger remedies in Germany and Ireland, but much more responsive to changing market
- Similar to electricity merger remedy: auction portion of generation as “Virtual Power Plants” e.g. EDF 2001-2012

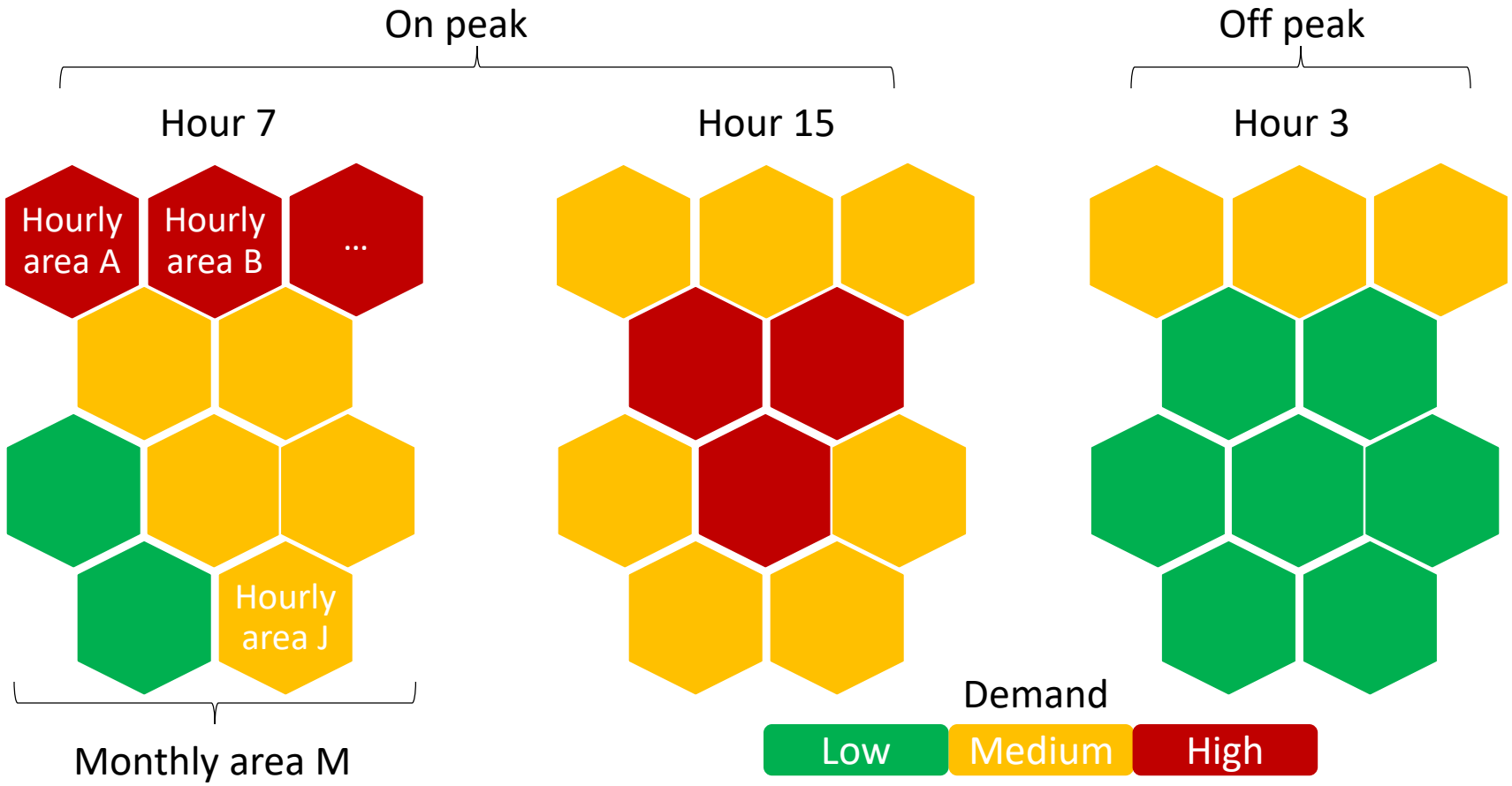
# Product design

- Product should be directly valued by consumer
  - Network throughput at particular location and time interval and latency
  - A market for throughput and latency not spectrum
  - Energy (MWh) in an electricity market
- Aggregation in both time and location to simplify and improve liquidity
  - Example: Particular cell over one hour (GB/h)

# All markets use single-price auction



# Multiple opportunities to trade: Yearly, monthly, hourly




*Yearly aggregates monthly aggregates hourly in time and location*

# Service provider estimates demand and stages purchase in three markets

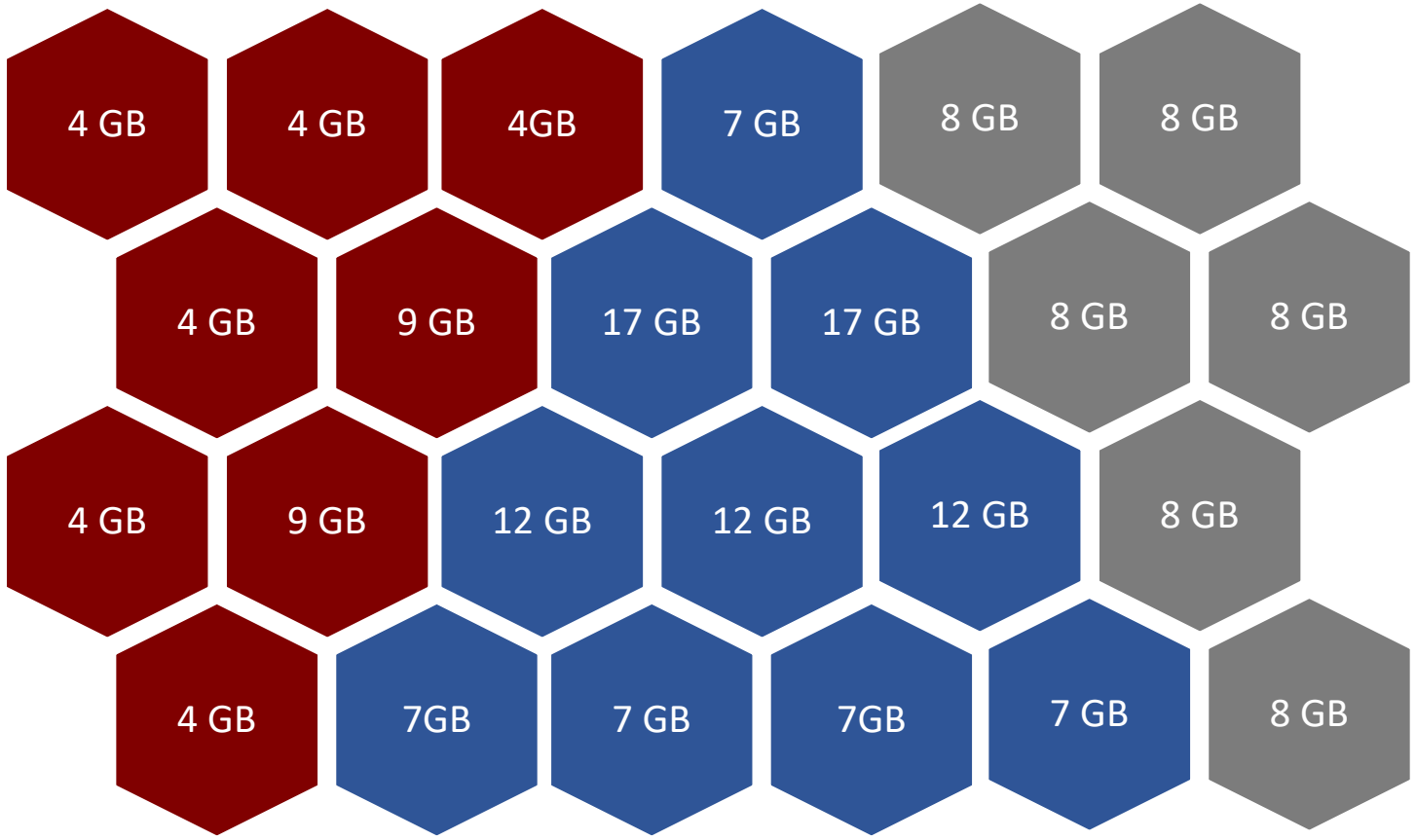
Yearly auction = buy 165 GB per hour, for every peak hour in the year, in the yearly area

# Refine estimate and make adjustment in monthly market

Yearly auction = buy 165 GB per hour, for every peak hour in the year, in the yearly area

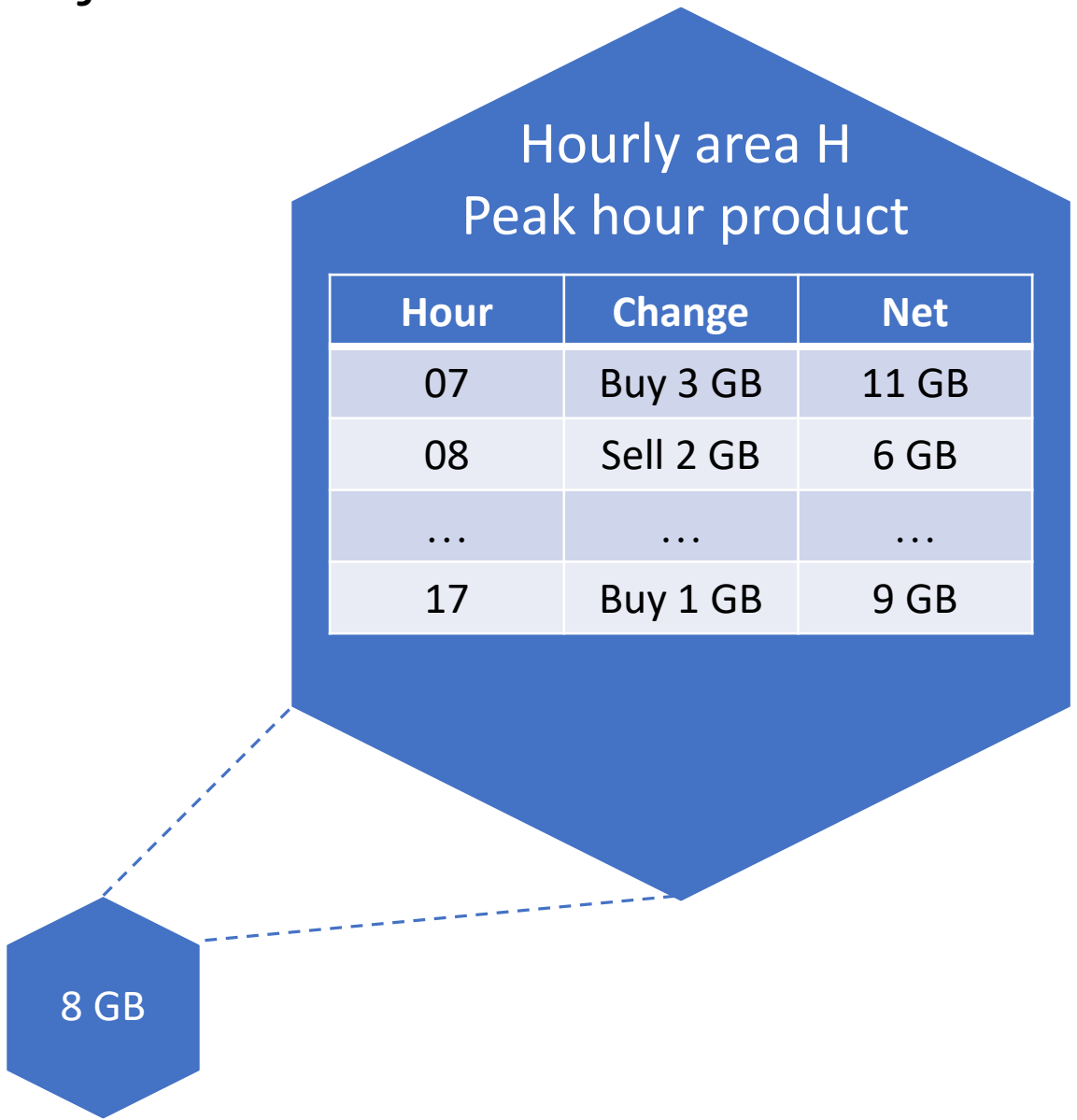
Monthly auction = sell 8 GB per hour, for every peak hour in the month, in the red area

Monthly auction = buy 15 GB per hour, for every peak hour in the month, in the green area




Monthly auction = buy 20 GB per hour, for every peak hour in the month, for the blue area

# Finalize estimate one hour ahead and make final adjustment to demand



## Sequence of auctions

## Example

- Three opportunities to trade
  - Reduces risk of service provider
  - Facilitates planning of service provider
  - Provides price transparency
  - Mitigates market power

# Prototype auction platform

- To illustrate market
- Demonstrate proof of concept

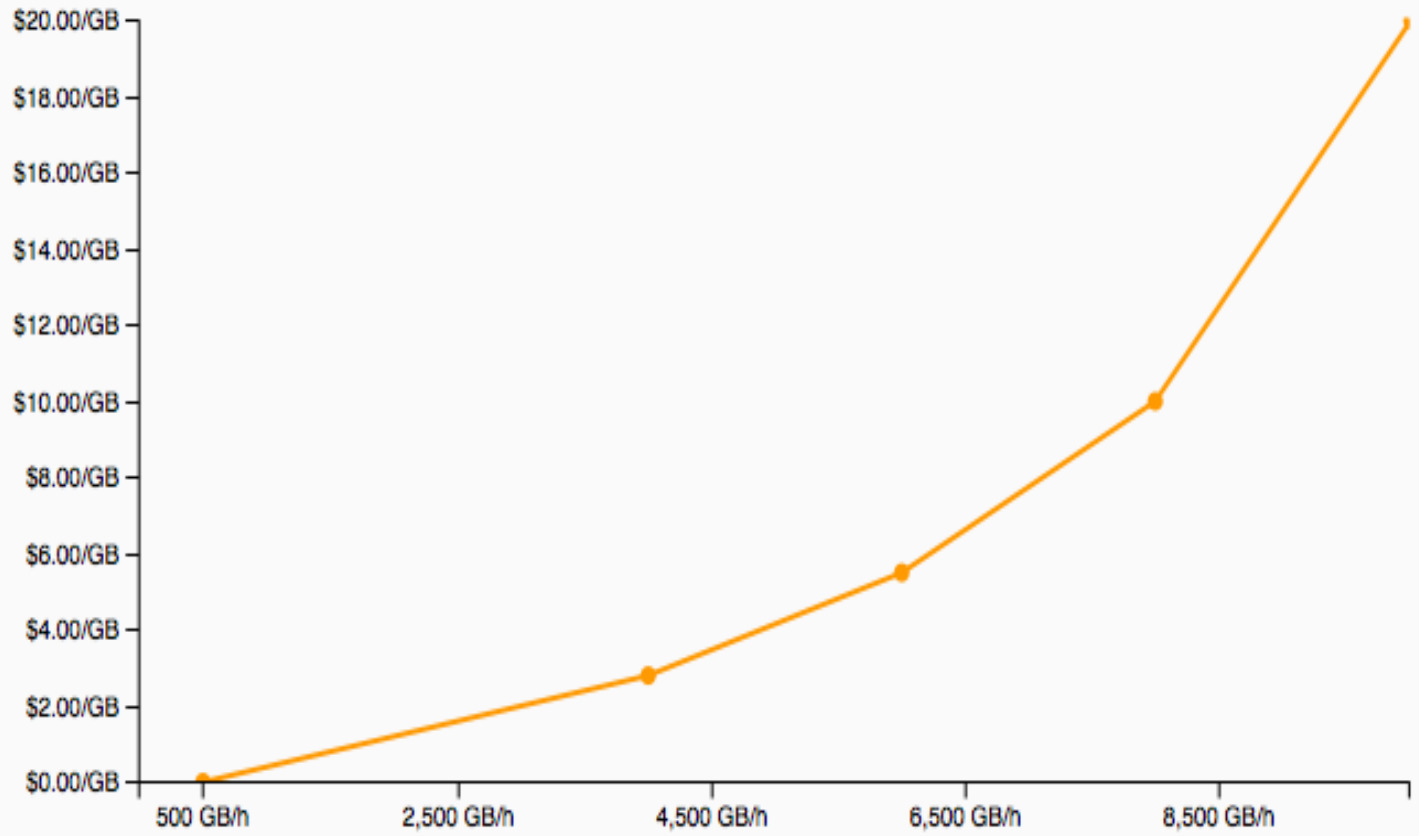
# Auction design

- Uniform-price auction for each product
- Preferences expressed as piecewise-linear strictly-decreasing demand curves
  - Consistent with underlying preferences
  - Unique clearing prices and quantities
- Yearly and monthly auctions: simultaneous ascending clock
- Hourly auction: sealed bid

# Current Published Supply Curve for Manhattan (Peak)

Select a product to view its supply curve calculated from the relative supply curve currently in the system.

Manhattan (Peak)



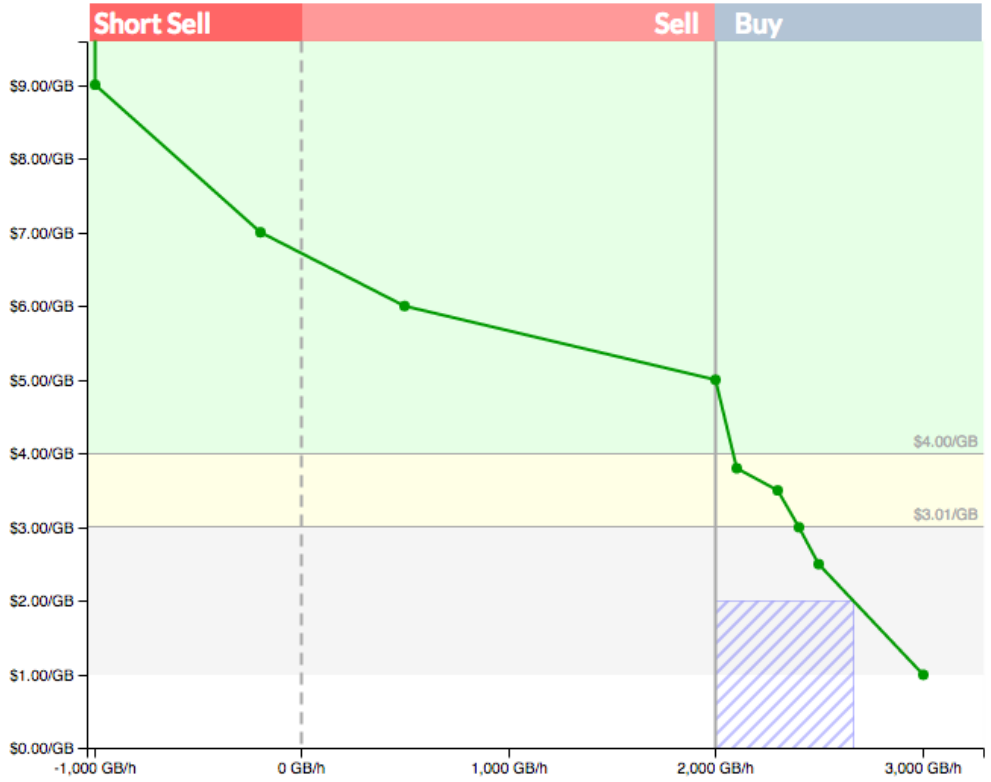
# Sample demand for bidder

## *Manhattan (peak) monthly*

**Manhattan (Peak)** At $ | /GB hold GB/h Add Cancel

**Your Forward Position:** 2,000.000 GB/h **Published Maximum Supply:** 10,000.000 GB/h

| | Price | Quantity | Change in Quantity | Commitment (180 hours) |
|---|---|---|---|---|
| *Future Rounds* | | | | |
| | $9.00/GB | -1,000.000 GB/h | -3,000.000 GB/h | -$4,860,000 |
| | $7.00/GB | -200.000 GB/h | -2,200.000 GB/h | -$2,772,000 |
| | $6.00/GB | 500.000 GB/h | -1,500.000 GB/h | -$1,620,000 |
| | $5.00/GB | 2,000.000 GB/h | 0.000 GB/h | $0 |
| *Current Round* | | | | |
| | ***$4.00/GB*** | ***2,083.333 GB/h*** | ***83.333 GB/h*** | ***$60,000*** |
| | $3.80/GB | 2,100.000 GB/h | 100.000 GB/h | $68,400 |
| | $3.50/GB | 2,300.000 GB/h | 300.000 GB/h | $189,000 |
| *Past Rounds* | | | | |
| | ***$3.00/GB*** | ***2,400.000 GB/h*** | ***400.000 GB/h*** | ***$216,000*** |
| | $2.50/GB | 2,500.000 GB/h | 500.000 GB/h | $225,000 |
| | ***$2.00/GB*** | ***2,666.667 GB/h*** | ***666.667 GB/h*** | ***$240,000*** |
| *Price Floor* | | | | |
| | $1.00/GB | 3,000.000 GB/h | 1,000.000 GB/h | $180,000 |



# Addressing hourly deviations between actual and purchased demand

- Neither system operator nor service provider can *control* demand perfectly to assure quantity consumed = quantity won
- Deviations are inevitable
- Final settlement should motivate service providers to limit deviations

# Hourly settlement for deviations

- $p_{hk}$ = price in hour *h* in area *k* that balances as-bid demand with estimated supply
- $q_{ihk}$ = total quantity bought by bidder *i* in hour *h* in hourly area *k* (includes yearly, monthly, and hourly net purchases)
- $Q_{ihk}$ = actual quantity consumed by bidder *i* in hour *h* in hourly area *k*
- $D_{ihk} = Q_{ihk} - q_{ihk}$ = deviation between actual quantity consumed and quantity bought
- *Tolerance* = percentage tolerance band (e.g., 10%); no penalty if deviation is within Tolerance
- *Penalty Factor* = a factor that is applied to square deviations above Tolerance
- Adjustment for deviations in the real-time market is $Adjustment_{ihk} = p_{hk} \times D_{ihk} + Penalty_{ihk}$ where
- $$Penalty_{ihk} = \begin{cases} 0 & if \ \frac{|D_{ihk}|}{q_{ihk}} \leq Tolerance \\ Penalty\ Factor \times p_{hk} \times D_{ihk}^2 & if \ \frac{|D_{ihk}|}{q_{ihk}} > Tolerance \end{cases}$$

*Standard efficient settlement if deviation is within Tolerance; penalty based on squared deviation outside of Tolerance to induce best estimate and control of demand to match winnings*

# Likely implementations

- Mexico (competition)
  - 90 MHz of 700 MHz set aside for open access
  - RFP to select implementer in 28 Sep 2016
- United States (public safety)
  - 20 MHz of 700 MHz set aside + $7 billion
  - RFP to select implementer in November 2016
- European Union (merger remedy)
  e.g. UK: Three & O2
  - Proposed mergers leading from 4 to 3 carriers
  - Merged entity allocates portion of network to open access