Infrastructure Sharing : Within Telecom and across infrastructure Sectors,

Rajendra Singh,
Senior Digital Development Specialist,
World Bank
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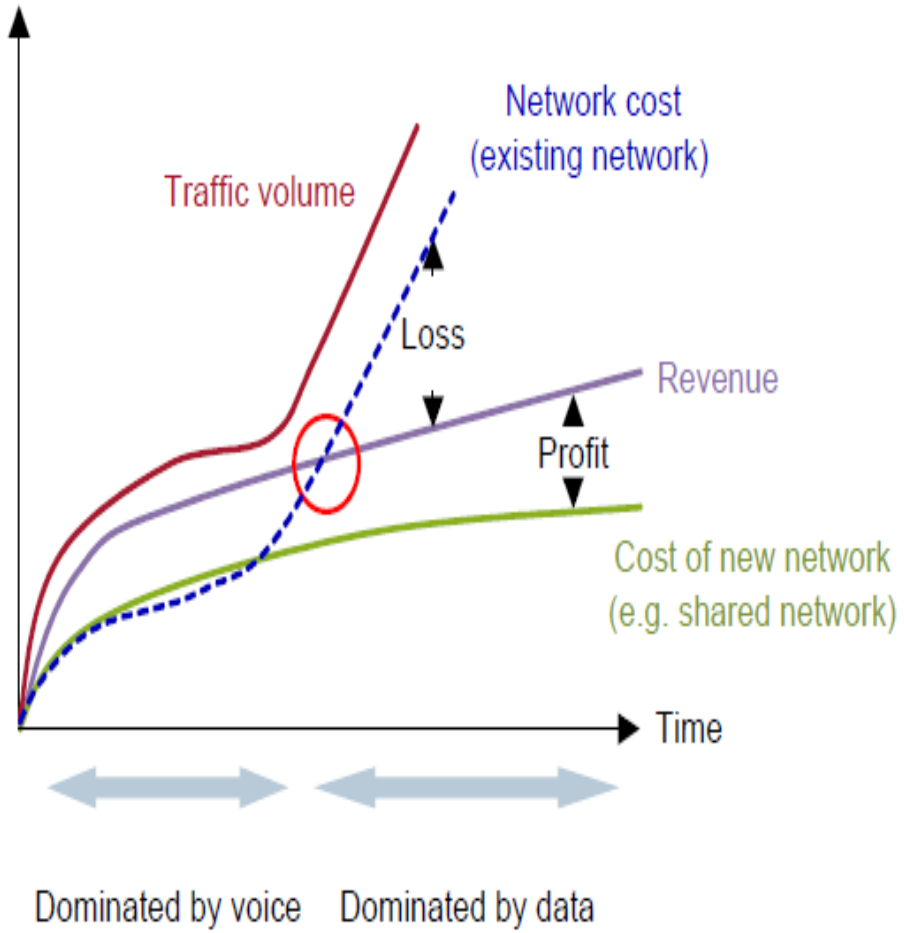
Outline

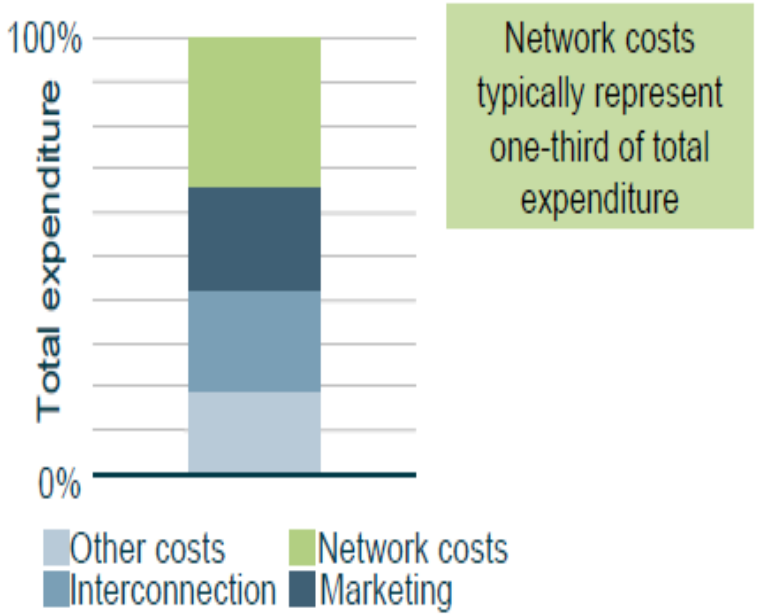
- RAN
- Physics of Spectrum
- Optical Fiber
- Tower and Power Supply

What Next ? Do we really Know?

- **Future is nearer than what we think**
- **Infrastructure competition may not be sustainable.**
- **Future may have type of services using digital connectivity platform which you and me may not imagine today.**
- **COVID, Conflict , and Climate have shown this**

Network Economics
(Source : Analysys Mason)





RAN

- Radio Unit (RU)- Due to disaggregation , virtualization, open interfaces, and with built-in intelligence, RUs can mitigate interference and increases the possibility of sharing the resources.
- Distribution Unit (DU) and Centralized Unit(CU)- They can move to Telecom Cloud and again sharing possibility increases.
- RAN sharing optimizes cost and leads to efficient utilization of resources.

The Shannon-Hartley Theorem (AKA Shannon's Law)

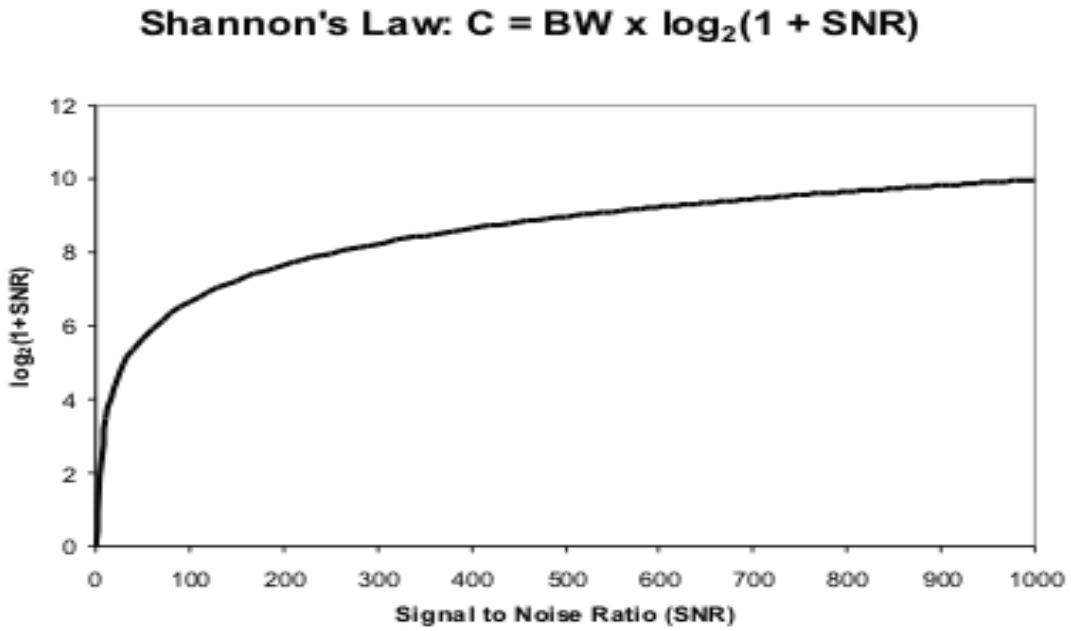
- First proposed by Ralph Hartley
- Proved by Claude Shannon in *Communication in the Presence of Noise* (Proc. Institute of Radio Engineers, vol. 37, no.1, pp. 10-21, Jan. 1949)
- Specifies the theoretical limit on the amount of information that can be transmitted via a communications channel (e.g. a radio link)
- **C = BW x log2(1 + SNR)**

  where:

  C = Capacity of a communications channel in bits per second (also known as the Shannon Limit)
  BW = Bandwidth of the channel in hertz (available spectrum minus allowance for filter rolloff and guard bands)
  SNR = Signal-to-noise ratio of the channel

Shannon's Theorem -What does it tell?

- Bandwidth(BW) increase is the only solution to enhance the channel capacity(C) beyond a limit



What does Shannon's Law tell us about spectrum policy?(contd)

Capacity increases linearly with bandwidth but only logarithmically with SNR.

It follows directly from Shannon's Law that nonexclusive licensing, plus interference mitigation techniques such as antenna gain requirements and cognitive radio technology, can maximize the number of high bandwidth links which can be created using a given region of the radio spectrum.

What does Shannon's Law tell us about spectrum policy? (Continued)

- Whenever an engineer sees a nonlinear term in an equation, he or she usually tries either to eliminate it (if linear performance is necessary) or take advantage of the nonlinearity.
- By implementing "courteous" spectrum sharing and interference avoidance, radios can be used to keep SNR above the "knee" in the curve
- At the same time, sharing of spectrum (nonexclusive licensing) allows larger chunks to be allocated so as to maximize the linear term in the equation
- Allocating spectrum in larger chunks also avoids waste due to imperfect filtering

Market based approach

- Economists argue that auction is the best market-based approach for allocation of spectrum. Recently Prof Paul Milgram and Prof Robert Wilson got Nobel prize in economics in 2020 for their auction theory related to spectrum management.
- Few companies, which have very strong financial muscle power become the custodian of this spectrum and then block the innovation by small companies because they don't have billions of dollars to pay. Will you still call it that market forces work?
- This is the same story everywhere.
- Technologists should focus on innovative solutions by using advancement in the technologies.

Technology can solve the problem

- So far spectrum is being managed like 'Land’
- Technology developments like 'Cognitive radio’ and SDR are moving in the direction so that spectrum is managed like 'Sea’.
- No one owns Pacific ocean but all shipping companies use it subject to certain regulations.
- Same will happen in spectrum management and technology is moving in that direction.

Optical Fiber Capacity and Reduced Cost

- Optical Fiber technology is moving from DWDM to SDM
- Single Core to Multi Core Technology
- Capacity in single fiber is moving from TBPS to PBPS.
- Multiple OFCs on the same route will lead to inefficient utilization of resources.
- Following ‘Dig only Once’ policy the cost of OFC can be significantly reduced. This implies cross-sector infrastructure sharing between telecom and transport sector leads to cost reduction.

Electricity Transmission and Telecom Sector

- Sharing of surplus capacity of Optical Ground Wire (OPGW)
- SCADA System uses less than 0.1 percent of total capacity of OPGW
- Wherever possible, electricity transmission towers can be shared by telecom operators
- Induced voltage in the ground wire can power base station equipment. Typically, 100 mtr section of 400 KV or higher voltage transmission line can have sufficient induced voltage to power the equipment. PGCIL, India has conducted successful trials.
- It means electricity transmission tower can offer complete solution for tower, electricity supply, and optical fiber for X-hauling with very little incremental cost.

Summary

- Very high data traffic growth will further increase and infrastructure-based competition in the present form may not be sustainable.
- Disaggregation ,virtualization, open interfaces, and more and more intelligence in the network will lead to sharing of active networks
- Start moving spectrum management from ‘Land’ to ‘Sea’ approach because that will be more consistent with spectrum physics
- Optical fiber technological developments will lead to more and more sharing
- Finally , look into infrastructure sharing beyond telecom sector like energy and transport
- This all should lead to affordable broadband internet

Thanks- Q&A

Email : rsingh6@worldbank.org