What Constitutes a Useful Theory Result?

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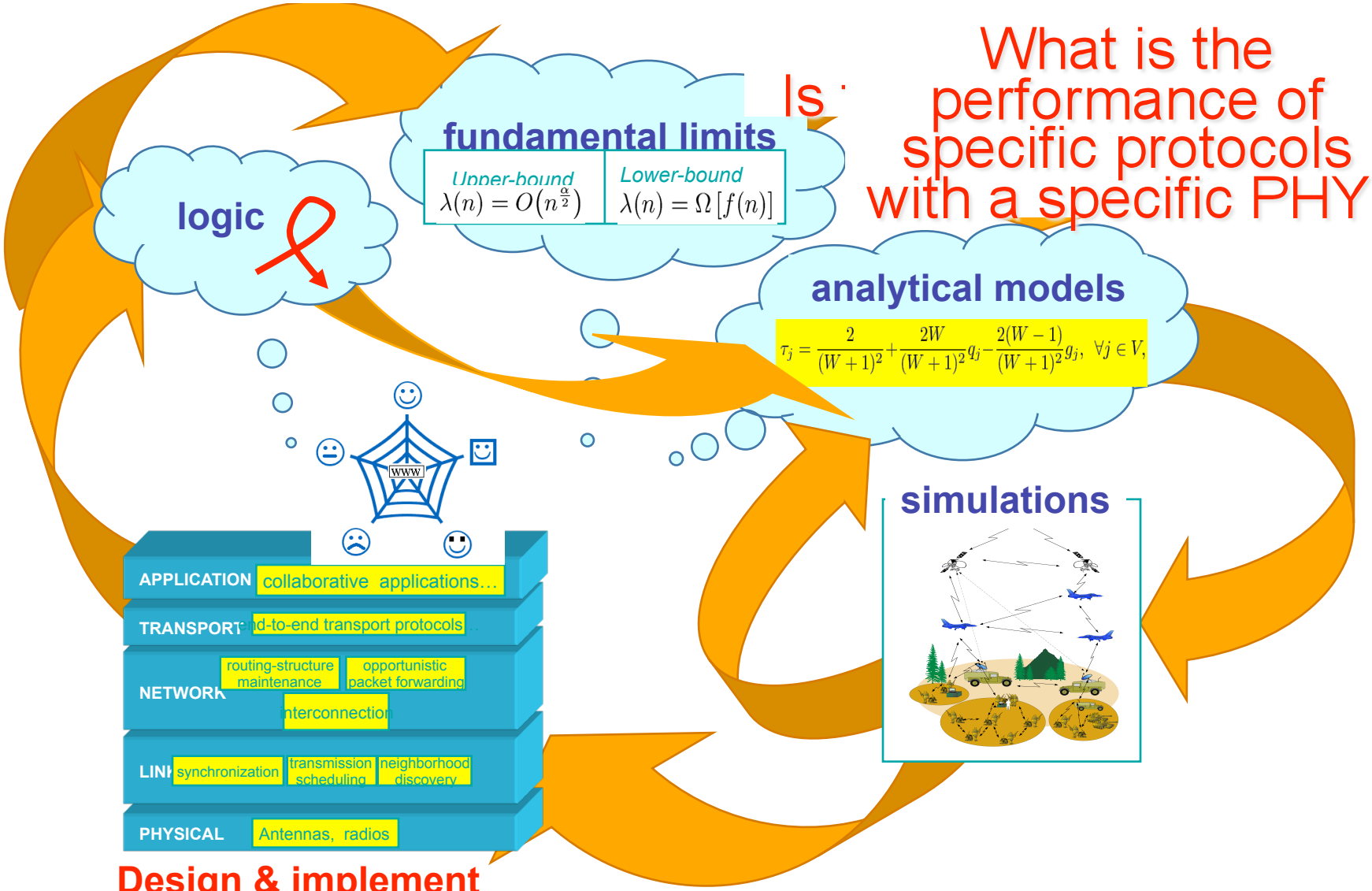
What Is Network Theory?



Design & implement

Mechanisms, protocols and architectures for future networks

A Useful Theoretical Result

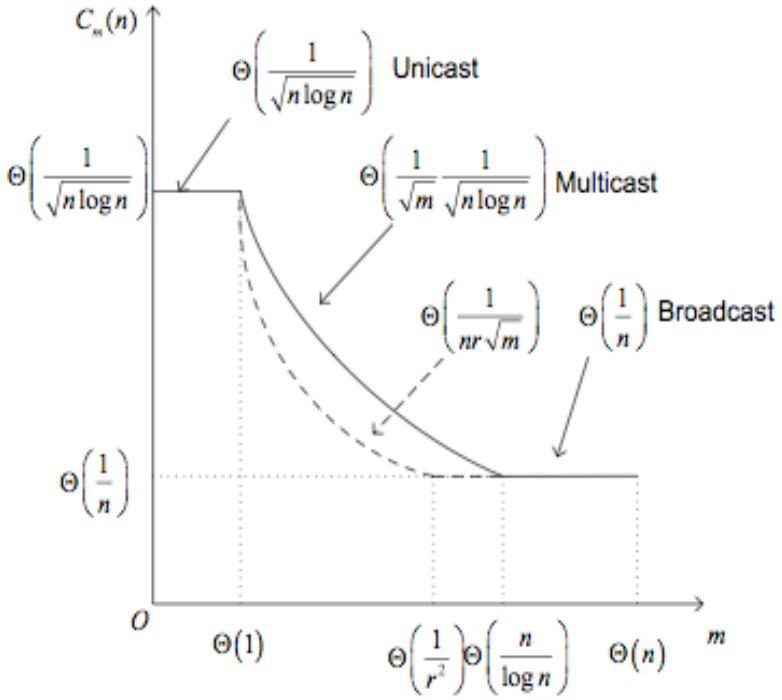
- **It is defined based on the intent of the model!**
- Must capture key aspect(s) of the logic, fundamental limit, or performance of algorithm, protocol or network architecture.
- Does not have to solve the precise implementation problem at hand.
- Can be translated into meaningful insight for design or implementation direction.

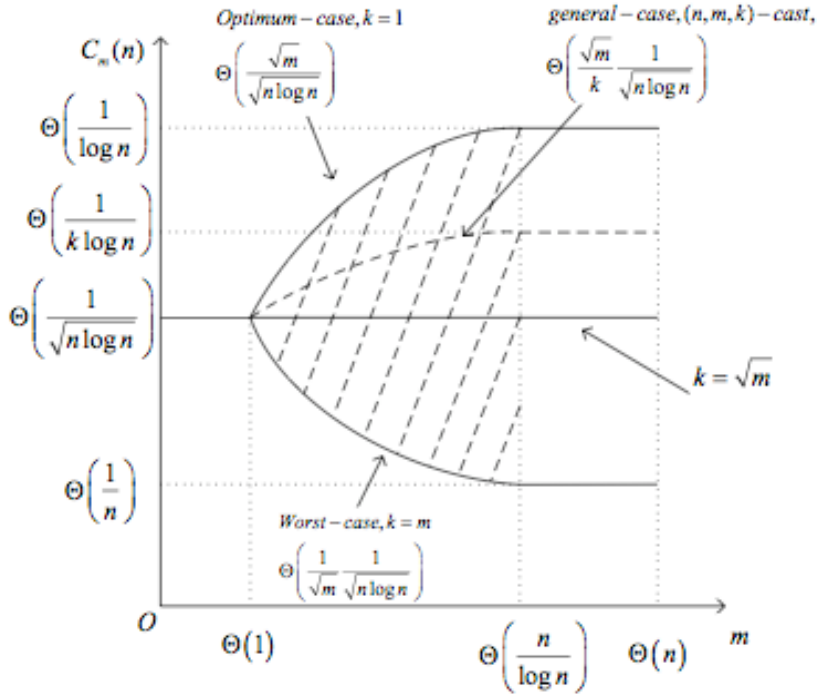
Some (Old) Examples

- **Logic:**
  - Liveness and safety of ARQ protocols (selective repeat vs GBN vs stop-and-wait) and convergence of routing protocols.
  - Nobody would design a window-based ARQ that just accepts pkts if there is buffer space at the receiver.
- **Performance:**
  - Poisson approximations in modeling of channel access (ALOHA vs CSMA vs BTMA vs CSMA/CD). Comparison among these protocols was very useful even with magical secondary channel for ACKs and Poisson sources.
  - Gallager's necessary & sufficient conditions for optimum routing. Cannot be attained in practice but it is a useful upper bound.
- **Limits:**
  - Order capacity of networks that embrace or avoid MAI

Recent Example 1: Taking a Hint from Capacity Results

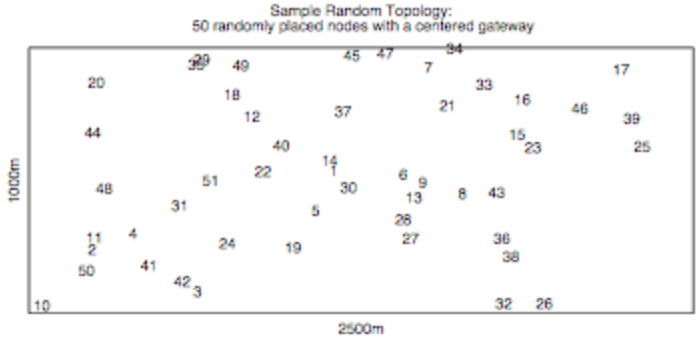
Z. Wang, H. Sadjadpour and J.J. Garcia-Luna-Aceves, ``A Unifying Perspective on The Capacity of Wireless Ad Hoc Networks," *Proc. IEEE Infocom 2008*, Phoenix, AZ, April 15--17, 2008.



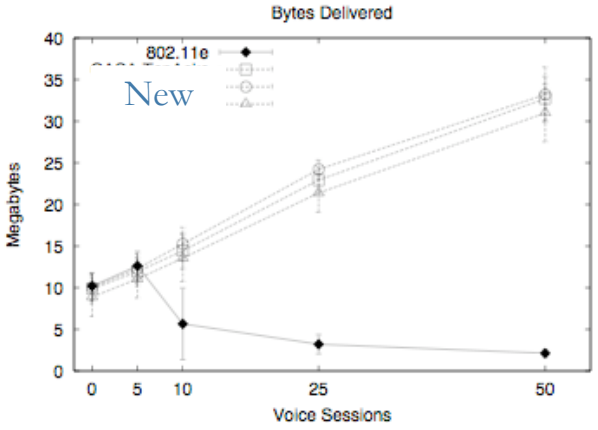


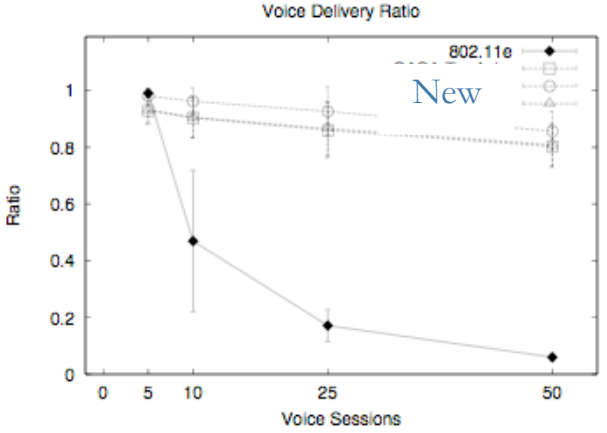
- Signaling overhead of routing protocols should be close to $\Theta(1)$ ⇒ Confine signaling to "regions of interest!
- Anycast & manycast ⇒ We MUST use in-network storage to bring or send content from/to nearest nodes

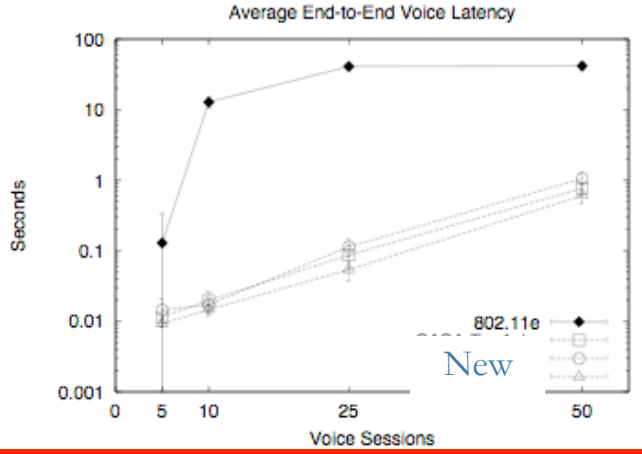
Recent Example 2: Schedule-based Access with Reservations

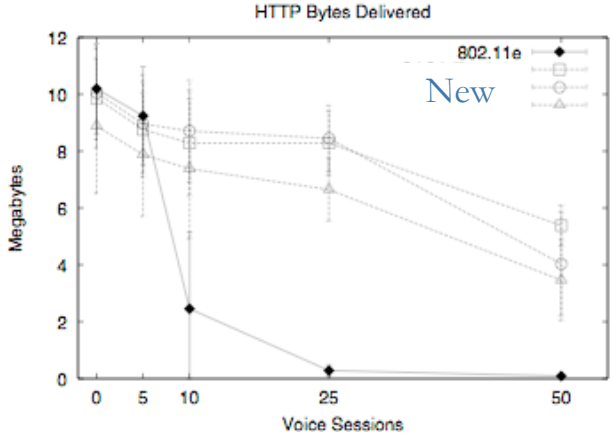


- ✓ 50 nodes placed randomly
- ✓ 50 HTTP flows, varying CBR flows
- ✓ Traffic to central access point
- ✓ Static routes, no coordination with MAC









- ✓ New scheme is self-synchronized distributed scheduling using reservations.
- ✓ Makes wireless mesh voice possible!
- ✓ Provides far better performance than 802.11e/n

Type of Theoretical Results Needed

- We should seek all three types!
  - Logic, limits and performance
- Role of simulation models & analytical models?
- My wish list:
  - PHY-layer impact (many parameters!)
  - Cross-layer interaction
  - Impact of amount of state needed/used at each node
  - Impact of *many* cheap radios per node
  - Embracing MAI (i.e., use concurrency in channel access and multihop dissemination)
  - Consider all resources (bandwidth, storage & processing)

Thanks!