# SENSE AND RESPOND THEORETIC FUNDAMENTALS

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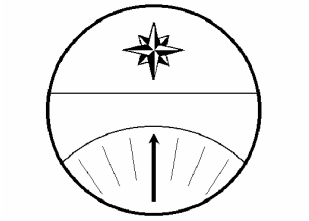


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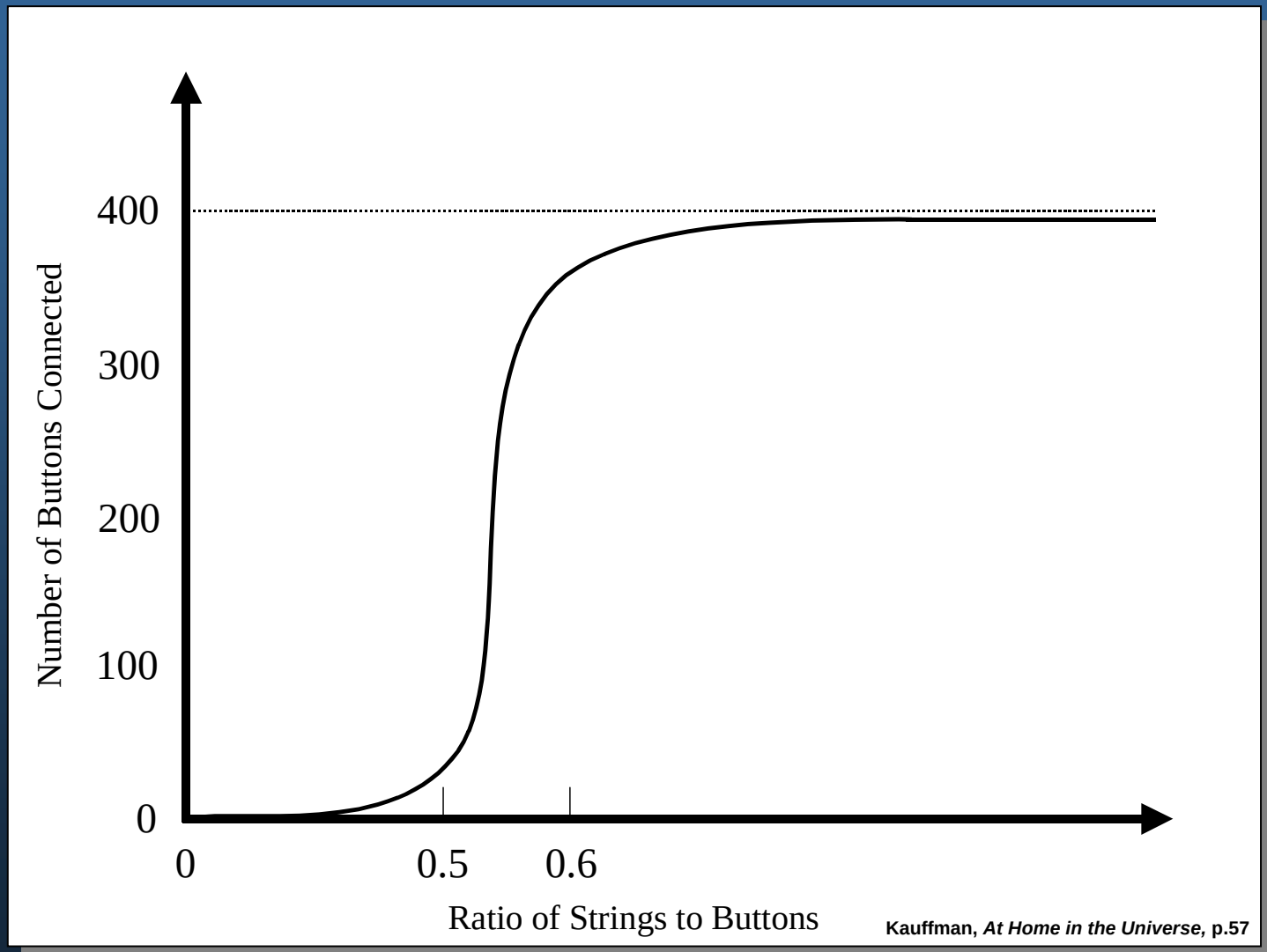
# Central Ideas

- Exploitable properties of Complex Networks
  - Hubs/Spokes distributed by Power Law
  - Tipping Points in dynamic structure
- Networks better than chains in complex environments
  - Inherent adaptation v. engineered optimization
- Demand as complex network control signal
  - Derived from consumptive behavior, e.g., combat

*Demand Networks* v. Supply Chains

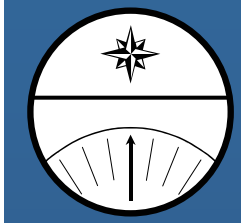
# Erdös Connectivity Profile




Kauffman, *At Home in the Universe,* p.57

# Important Network Properties

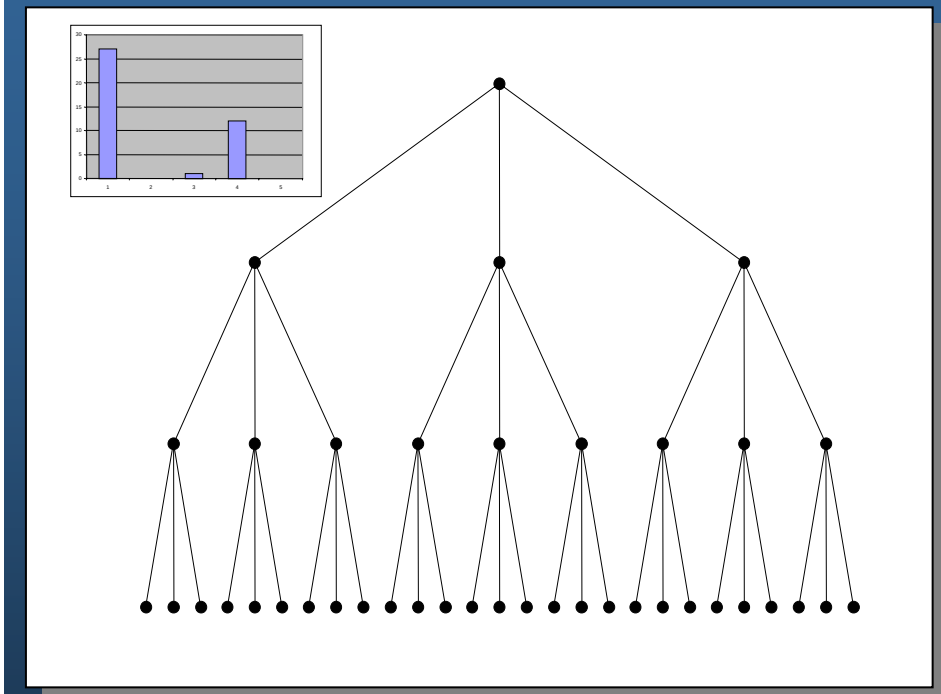
- Degree
  - Distribution of links among nodes
- Clustering
  - Local, mutually supporting link structure
- Network Effects
  - Indirect compounding feed-forward/ feedback
  - Autocatalysis
- Tipping Points
  - Rapid accumulation of network effects
- Susceptibility
  - Loss of network effects due to node, link removal
- Neutrality
  - Additional latent (not necessarily redundant) node and link structure

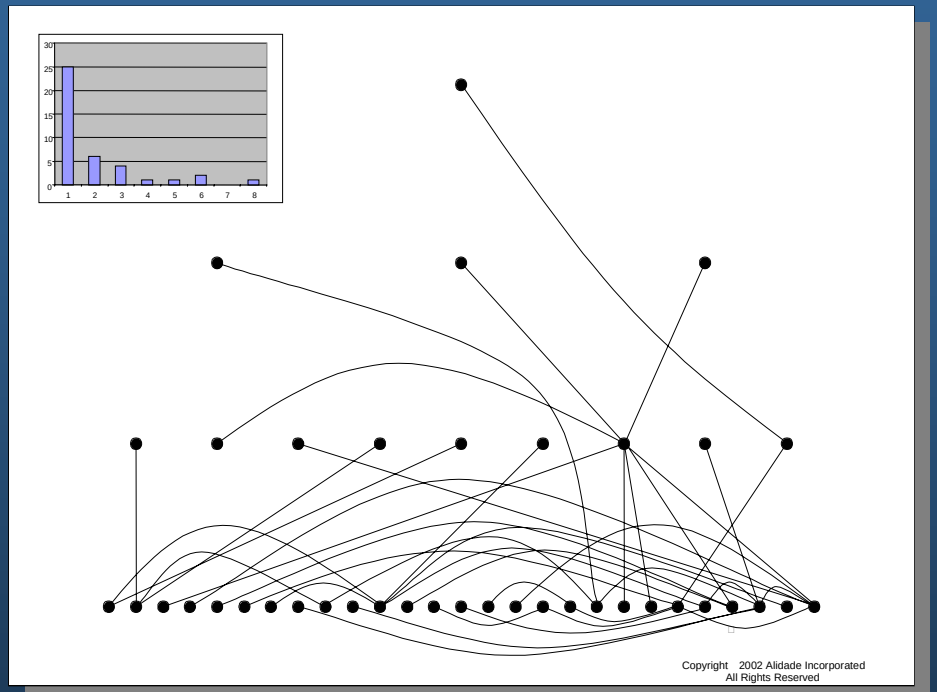


# Thumb Rules for Analysis and Experimentation

| Property | Range | Effect |
|---|---|---|
| Number of Nodes, $n$ | $n$ > ~100 | Network effects unlikely to occur with $n$ < 50 |
| Number of links, $l$ | $l$ < ~2$n$ | $l$ << 2$n$, too brittle<br>$l$ >> 2$n$, too much overhead |
| Degree Distribution | Skew Distribution | Adaptive control, recombination |
| Largest Hub | < 100 links | Hub appears, recedes by reconnection 5% of links |
| Average Path Length | O($n$) | Short distances even for large networks (e.g., $10^4$ nodes $\rightarrow$ Average Path Length = ~4) |
| Clustering | Skew Distribution | Adaptive hierarchy, modularity |
| Susceptibility | Low (random removal)<br>High (focused removal) | Hubs must be kept obscure until needed<br>FP an issue once hubs identified |
| Neutrality | High | Increased network effects, decreased susceptibility, tipping points |

# Chains v. Networks






## Chain

Too brittle, long paths, low clustering, simple pattern, simple control, scaled

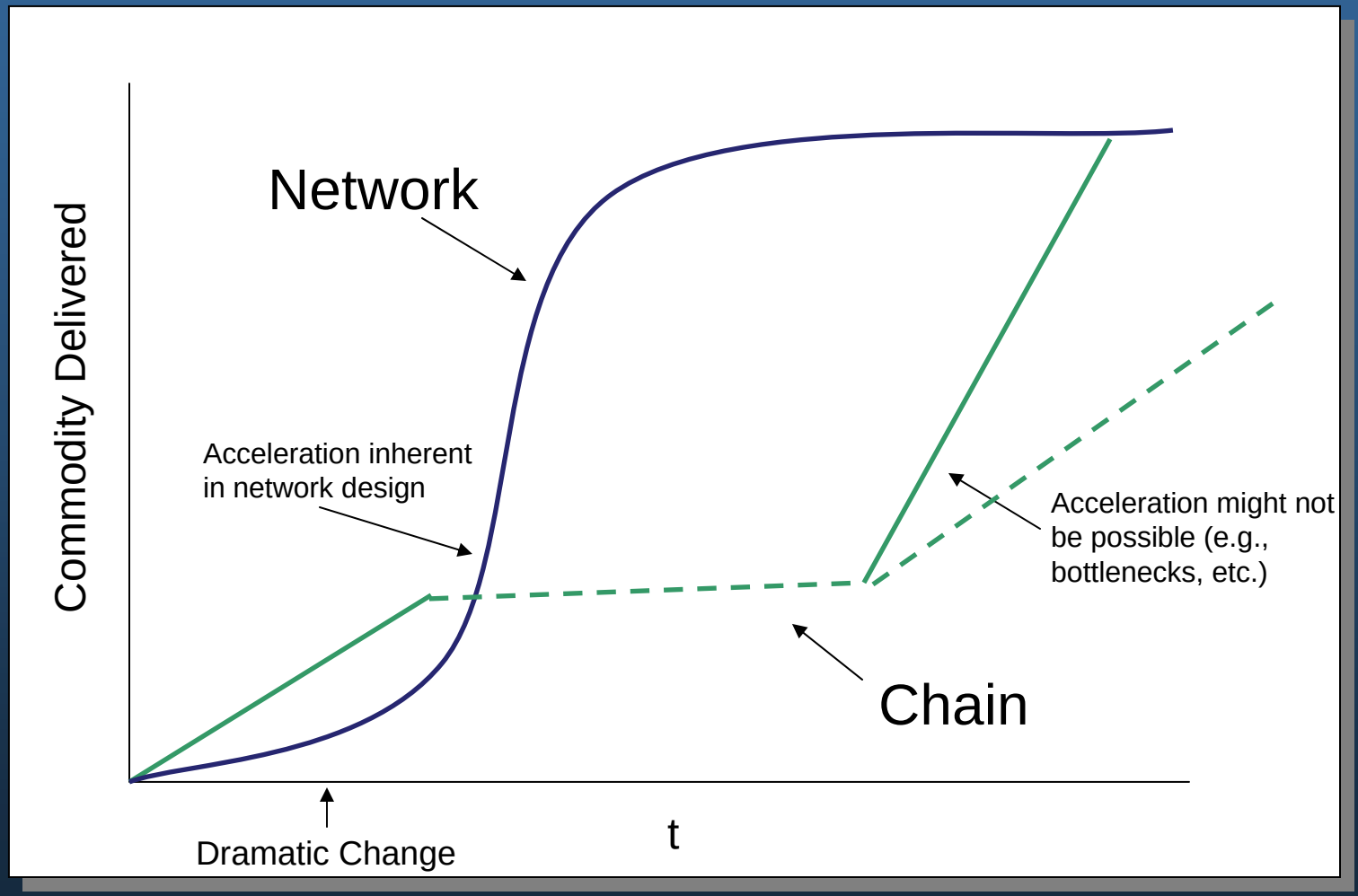
"business end" most poorly connected, hard to reconfigure or change flow

## Network

Very robust, short paths, low clustering, complex pattern, complex control, scale free

"business end" best connected, natural to reconfigure or change flow

# Chains v. Networks w/ Uncertainty



# Supply v. Demand

- "Supply" perspective rooted in Industrial Age Logistics
  - Paragon is WalMart Model
  - Focus is on decreasing time or cost of delivery
    - Using IT to refine the supply chain by shortening the chain (disintermediation) and better prediction
  - Still has an upper limit of efficiency
  - Would function poorly under the type of uncertainty and scales we see in combat operations
- "Demand" is the real control signal
  - Closely related to Commander's Intent
  - Intimately related to unfolding battlefield operations

# Supply v. Demand w/ Uncertainty

- Supply process requires great predictability
  - Depends on statistics of stability
  - Lagged reaction to dramatic changes
- Demand
  - We have the best insight on the control signal
    - S&R becomes a “learned response”
  - Enemy has the hardest task of the Information Age: determining our demand signal by observation

# Sense & Respond Logistics

- Demand Networks rather than Supply Chains
  - Turn units in the main effort into nodes of preferential attachment
  - Quickly reconfigure network and hubs as situation unfolds
  - Closely tie logistics to operations through Commander's Intent
  - Obscure the intent with a distributed logistics train while operating without a centralized dump
  - Adaptive Learning v. Reactive Planning

# Questions?