On Evolution of C2 Network Topology

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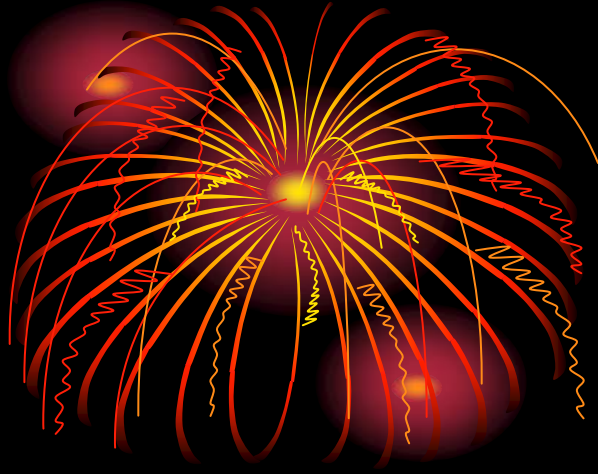
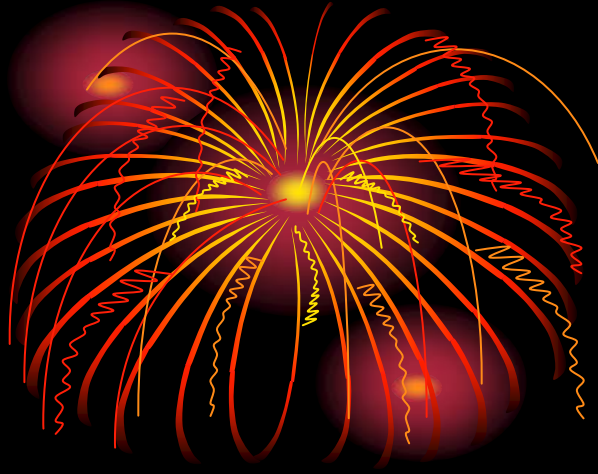
Introduction



- *C2 networks*
  - *Offer geographical decentralization, concealment, adjacency and rapid reorganization of C2 elements*
  - *Restricts complexity and uncertainty*
  - *Increases the probability of correct decision-making*

Introduction



- C2 networks
  - Hard to control its own structure
  - Hard to be adaptive in the respects of self-heal, self-organization , self-evolution
  - Typical topology models are far away from the demands

C2 Network Requirements

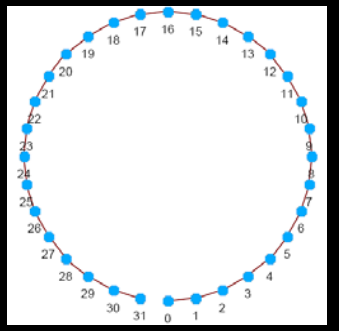
- Adaptivity
  - dynamic evolution
- Reliability
  - fault tolerance and self healing
- Credibility
  - flexible, trusted network
- High-efficiency
  - quality of service, availability under attack

Topology Metrics

- *Link to node ratio≈2*
- *A skew degree distribution*
- *Small mean path length*
- *Clustering coefficient≈0.1-0.25*
- *A skew betweenness distribution*

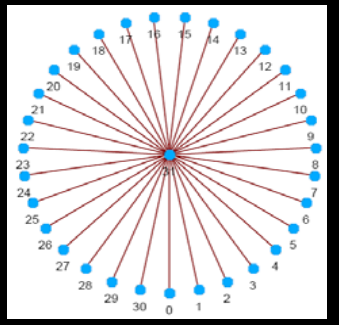
Regular Networks

- Chain Coupled Networks
  - Cheapest and simplest networks
  - Brittle with little redundancy
  - Unbearable mean path length
  - Degree is close to two
  - Clustering coefficient→0



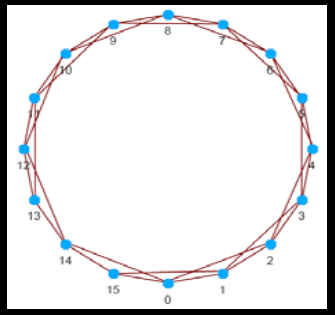
Regular Networks

- Star Coupled Networks
  - Cheapest and simplest networks
  - Mean path length is short
  - Single point failure
  - Other flaws are similar to chain topology



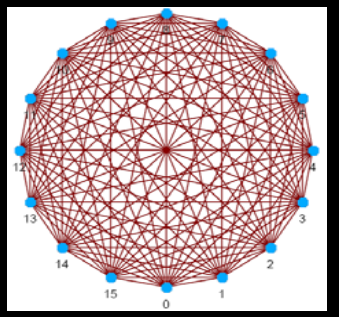
Regular Networks

- *Nearest-Neighbor Coupled Networks*
  - *Mean path length is overlong*
  - *Uniform degree distribution*
  - *Clustering coefficient drops with accretion of network size*



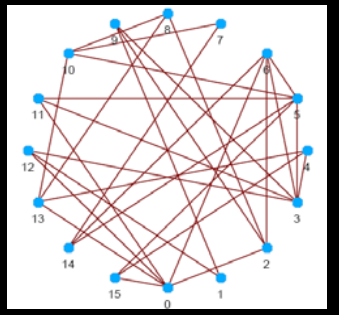
Regular Networks

- *Globally Coupled Networks*
  - *Most expensive with highest link to node ratio*
  - *Enormous number of decisions*
  - *Shortest mean path length*
  - *Top clustering coefficient*
  - *Not scale well*



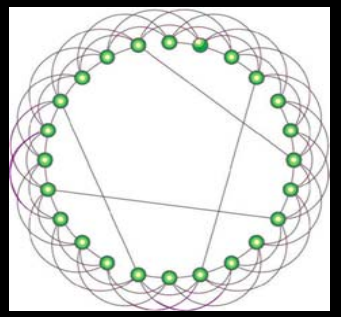
Random Networks

- *"Bell" curve degree distribution*
- *Relatively low mean path length and clustering coefficient with a large variation from node to node*
- *Vulnerable to attacks*
- *Little controllability*



Small World Networks

- *Adjustable clustering coefficient*
- *Most efficient class of network*
- *Degrees of all nodes are mostly close*



Scale-Free Networks

- *High clustering coefficient*
- *Small world effect with mean path length rising in direct ratio to lg(n)/lg(lg(n))*
- *A power law distribution*
- *Robust yet fragile*

Situation

- *Existing models are not practical to C2 networks*
- *Fundamental problems*
  - *No pointed theory on topology creation*
  - *No method to support dynamic reconstruction of a desired topology*
  - *No mechanism for credible topology*
  - *lack of model for performance guarantee*

Way out

- *Carry out the following work*
  - *C2 topology Characterization*
  - *C2 topology rule exploration*
  - *C2 topology modeling, resolution and construction*
  - *Natural evolutionary mechanisms of C2 topology*

Conclusions

- *Complex networks turn on a new light for topology study*
- *Existing topology theories fail to deal with topology modeling, control, quantitative analysis and optimization of C2 network*
- *Precise description, construction and evolution of topology is eager for opening out*

Thank you !