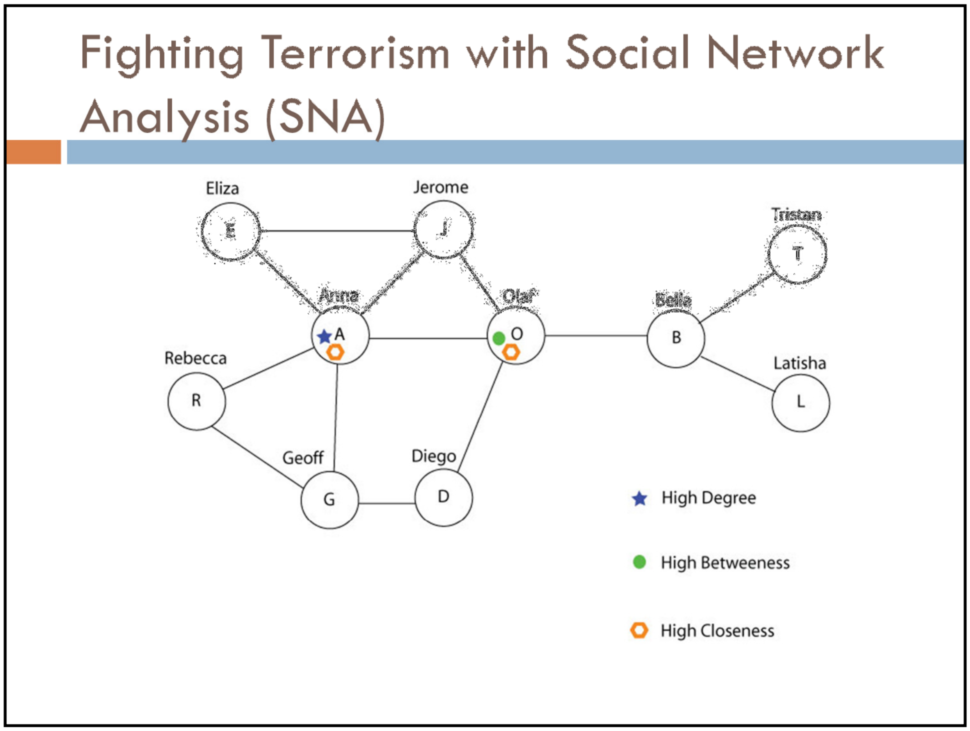
Fighting Terrorism with Social Network Analysis (SNA)

- Goals
  - Define Social Network Analysis (SNA)
  - Explain why SNA is important today
  - Explain how SNA experts use graph theory to analyze social networks
  - Explain the three methods that experts use to determine the leaders of a social network



After the 9/11 attacks, our government reorganized its intelligence efforts to improve our fight against terrorism. A significant result of this reorganization was the creation of the National Counterterrorism Center (NCTC), which was established to pull together all of the terrorism-related information obtained by each of the 16 separate intelligence agencies.

One thing the NCTC does is compile and analyze graphs similar to the one here but on a much larger scale.

Yet, even with this new system in place…

December 25, 2009
Abdul Mutallab, 23-year-old Nigerian man
Northwest Flight 253 to Detroit
With explosive material attached to his body
As plane descended toward Detroit Metropolitan Airport, Abdul Mutallab set off the device
Bomb failed to ignite
Sparked a fire instead of an explosion
This man claimed to have received training and instructions from al-Qaida operatives in Yemen.

One month prior to this attack, Abdul Mutallab's father warned U.S. officials of concerns about his son's religious beliefs.

Connecting the Dots

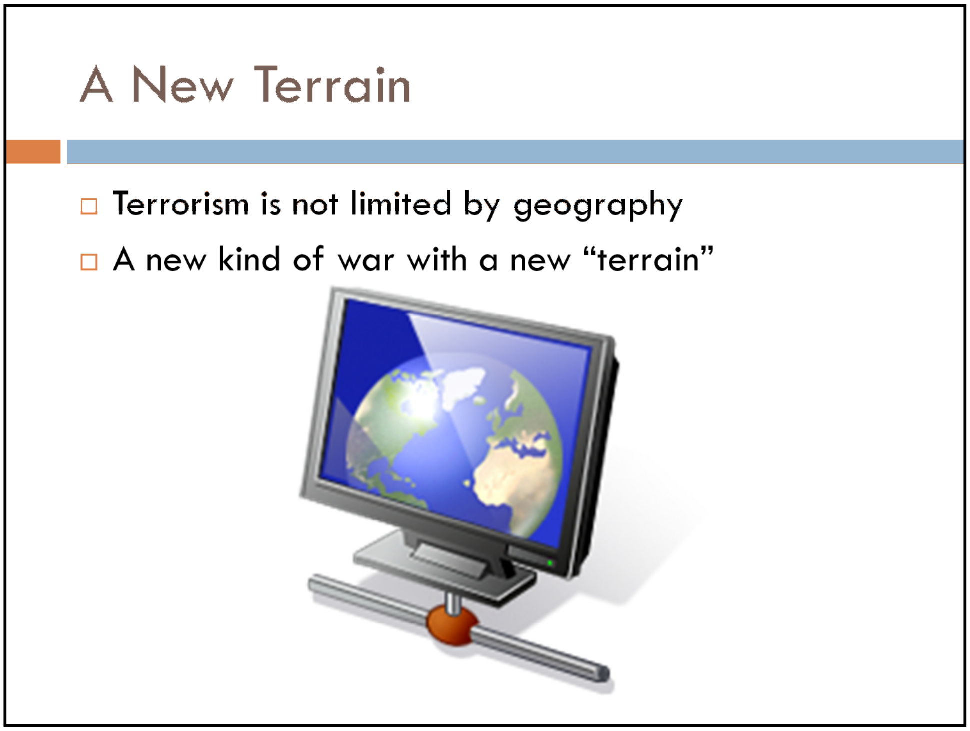
- Voice of America report
- http://www1.voanews.com/english/news/usa/Christmas-Day-Attack-Highlights-US-Intelligence-Gaps-80730167.html (PDF)

Voice of America news reported the following after the Christmas Day attack:

“Current and former intelligence officials argue that the information on Abdulmutallab was in fact shared. But, as former CIA director General Michael Hayden tells VOA, it was never properly analyzed - connecting the dots, as intelligence officers like to call it - to raise warning signals.”

“They didn’t connect the dots.” How the NCTC “connects the dots” and what they do with them is what I’m going to talk about today.

"‘These dots look very powerful and connected in retrospect,’ he said. ‘But given the vast ocean of dots that analysts have to work with prospect, this is very daunting task every day, and for the most part they get it right. Here they didn't. They didn't connect the dots, or at least didn't connect them in time to take action.’“



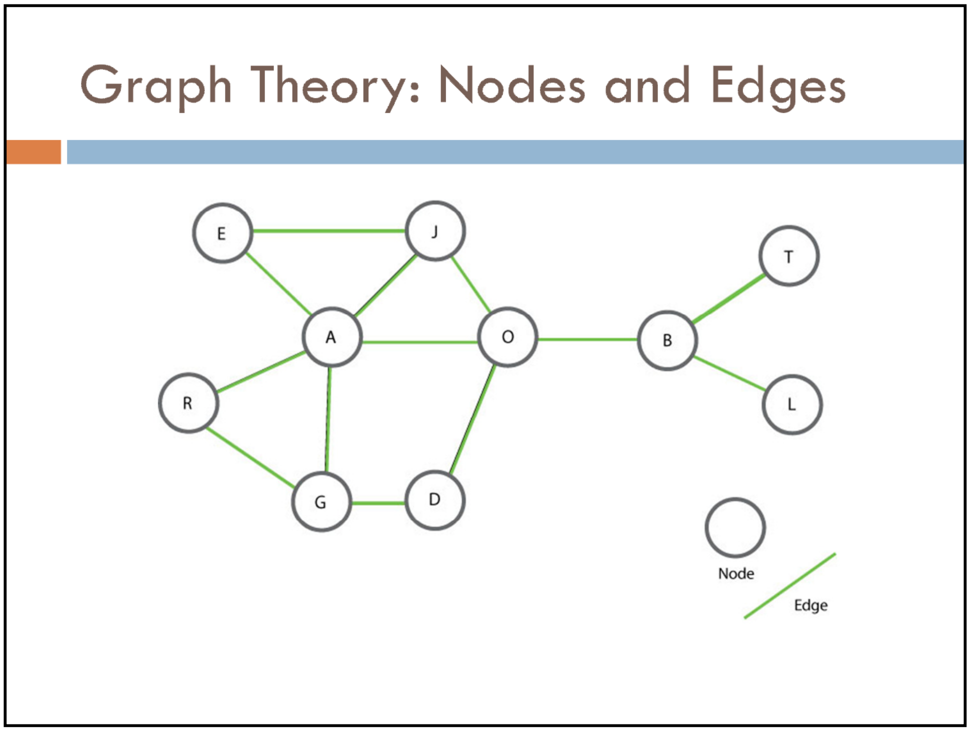
Terrorism is a new kind of war not limited by geographic terrain.

Terrorists can live anywhere on the globe and still remain connected to their leaders. This means they can attack anyone, anywhere, and anytime.

To understand how terrorists work and how to fight against them, we need to understand their social networks, or the new “terrain.” A social network is a term used to describe the connections and relationships among the different members of a network. To understand a social network, we need to know

- how these networks operate
- how each person in the network is related to the others
- and how communication travels among members

Before we can talk about those concepts, you need to know some basic concepts and terminology of graph theory, because graphs are how SNA experts work with social networks.

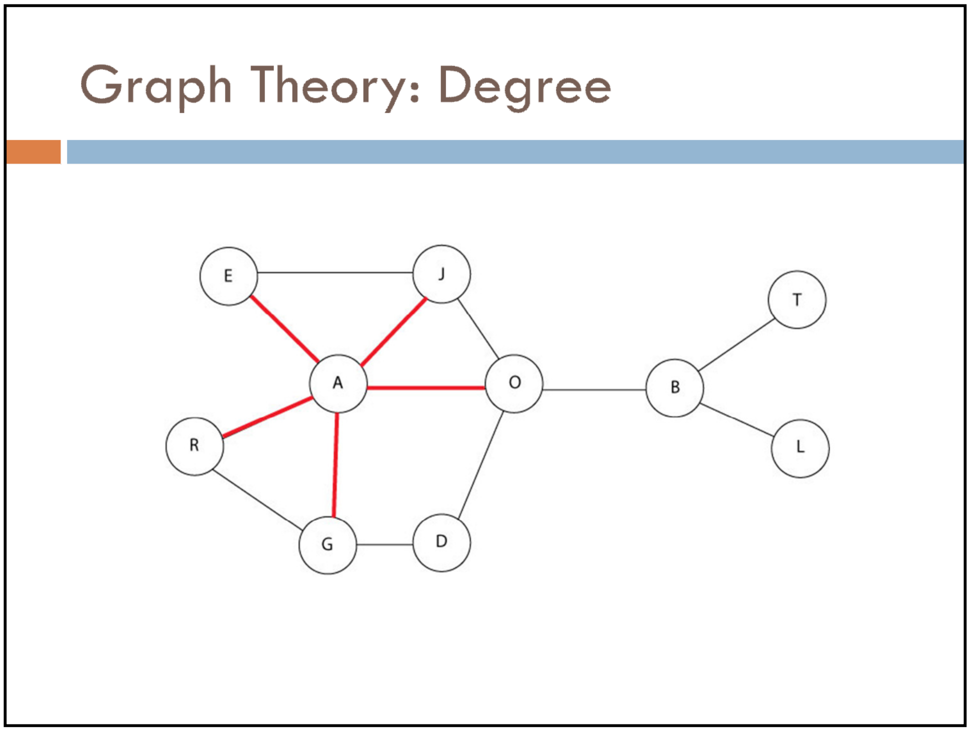


In graph theory, a graph is different from the graph of a continuous function.

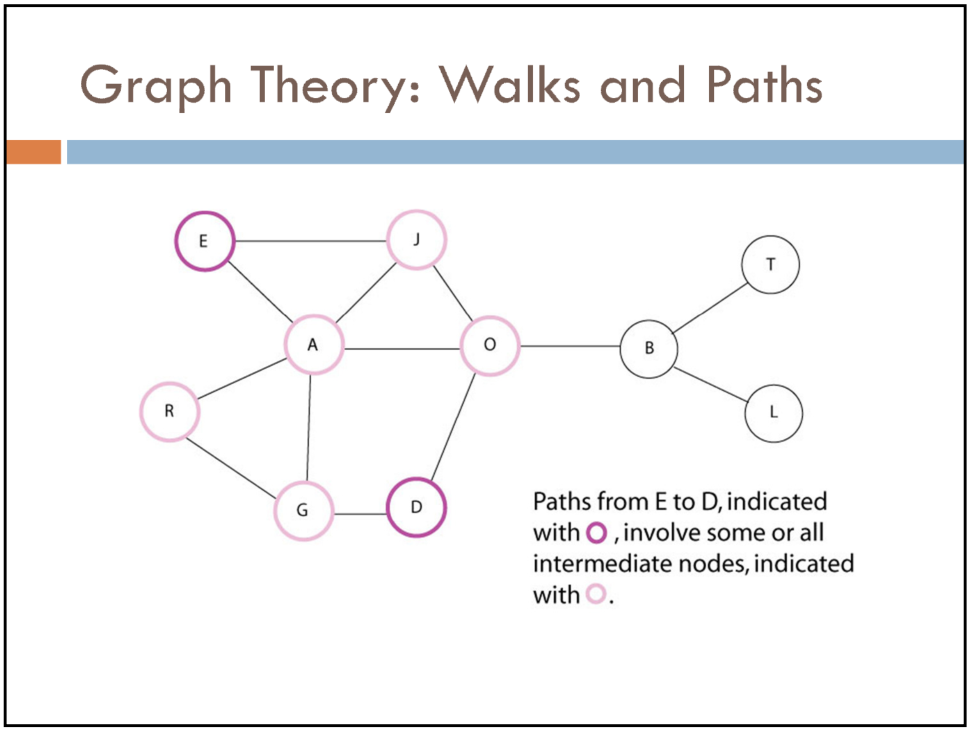
The graphs used in social network analysis are comprised of disparate objects and the relationships between them.

The objects are represented by nodes and the relationships are represented by edges.

A <u>graph</u>, such as the one here, consists of two finite sets: a set of <u>nodes</u> (circles) and a set of <u>edges</u> (lines). Each edge is associated with two nodes called its endpoints. So edges connect nodes. An edge is <u>incident</u> on each of its endpoints.



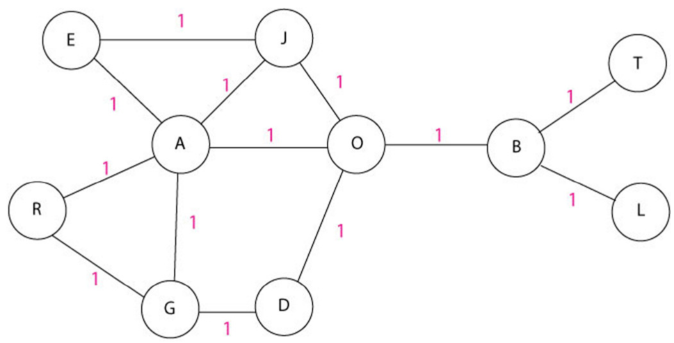
The degree of a node is the number of edges incident on that node, i.e. the number of direct connections it has.



A walk from one node to another is a finite alternating sequence of adjacent nodes and edges. Imagine starting at node E and crossing an edge to J. You then cross another edge to O. Continue in this way until you reach D. The walk is EJOD starting at E and “stepping over” J and O and proceeding to the ending node: D. The intermediate nodes J and O are like stepping stones.

A Path from one node to another is simply a walk with no repeating edges. EJOD is actually a path.

Graph Theory: Distance



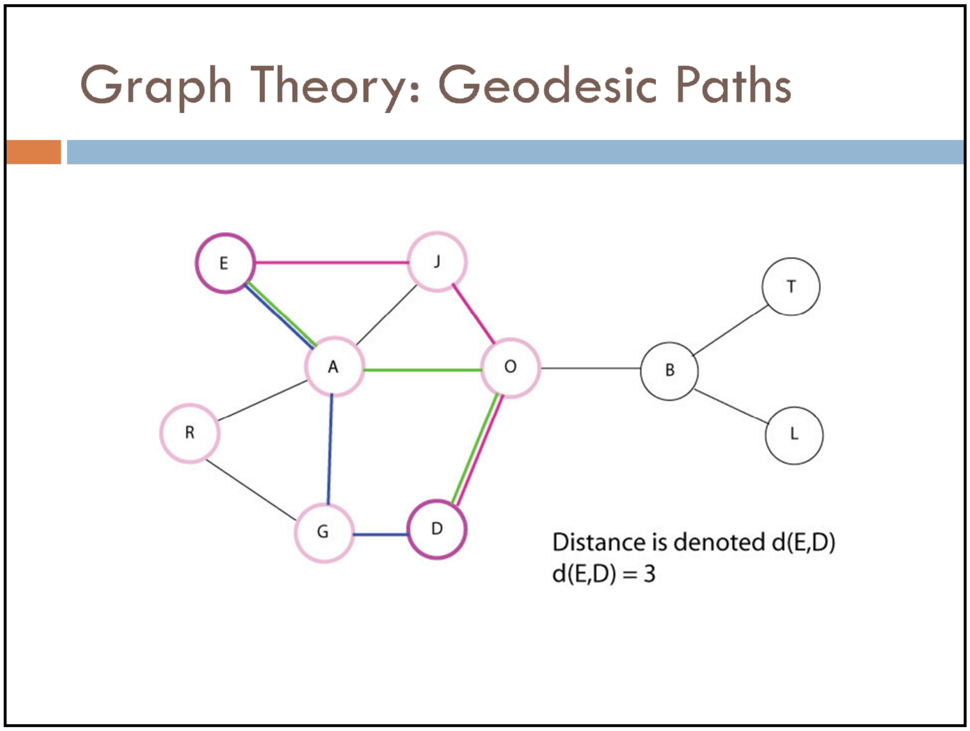
To have a distance between two nodes, the nodes must be connected. Two nodes are connected if there is a walk between them.

The distance between any two nodes is the number of edges that must be traversed to get from one node to the other. Each edge of a walk or path counts as 1 unit.

Possible paths:

EAGD(3); EAOD(3); EAJOD(4); EARGD(4); EJOD(3); EJARGD(5); EJAGD(4); EJAOD(4); EJOARGD(6)

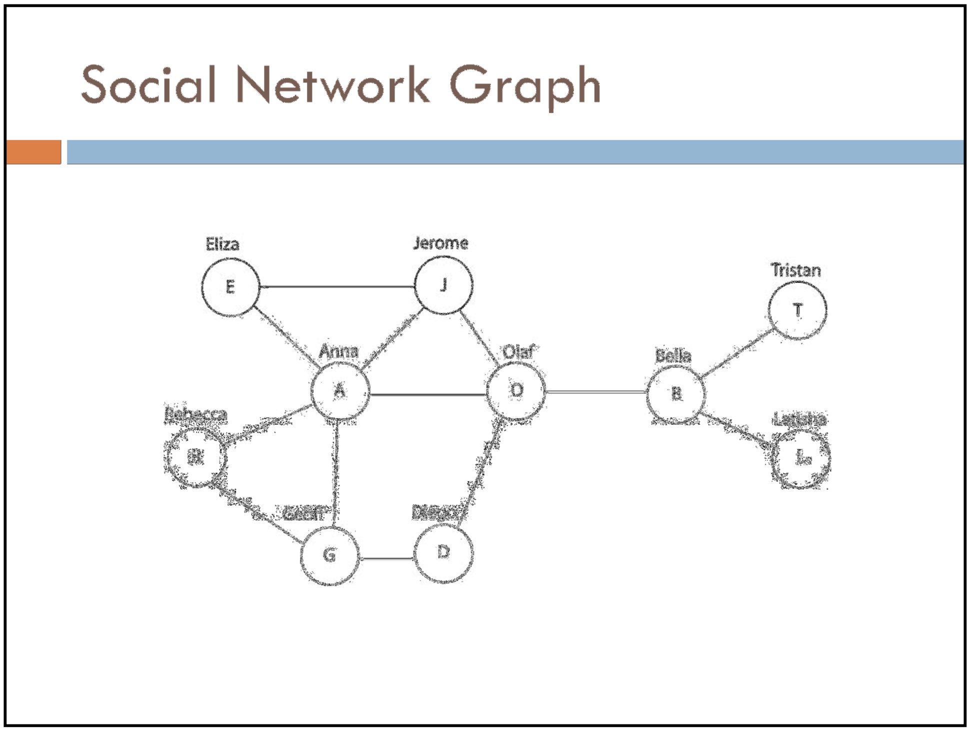
The shortest distance between two nodes is called the geodesic path. Every edge is a geodesic path of 1.



If the geodesic path from E to D requires traversing 3 edges, then the geodesic distance is 3. You may have more than one geodesic path. For example, starting at E, if you go through A, you could then go through either G or O before moving on to D. The distance is still 3.

Three Geodesic paths: EAGD; EAOD; EJOD
Other paths: EARGD (4); EAJOD(4); EJARGD(5); EJAGD(4); EJAOD(4); EJOARGD(6)

Geodesic Distance is denoted d(E,D) = 3.



In a social network, nodes represent people and edges represent the relationships between them such as "knows," "works with," "communicates with," "related to," "lives with," etc.

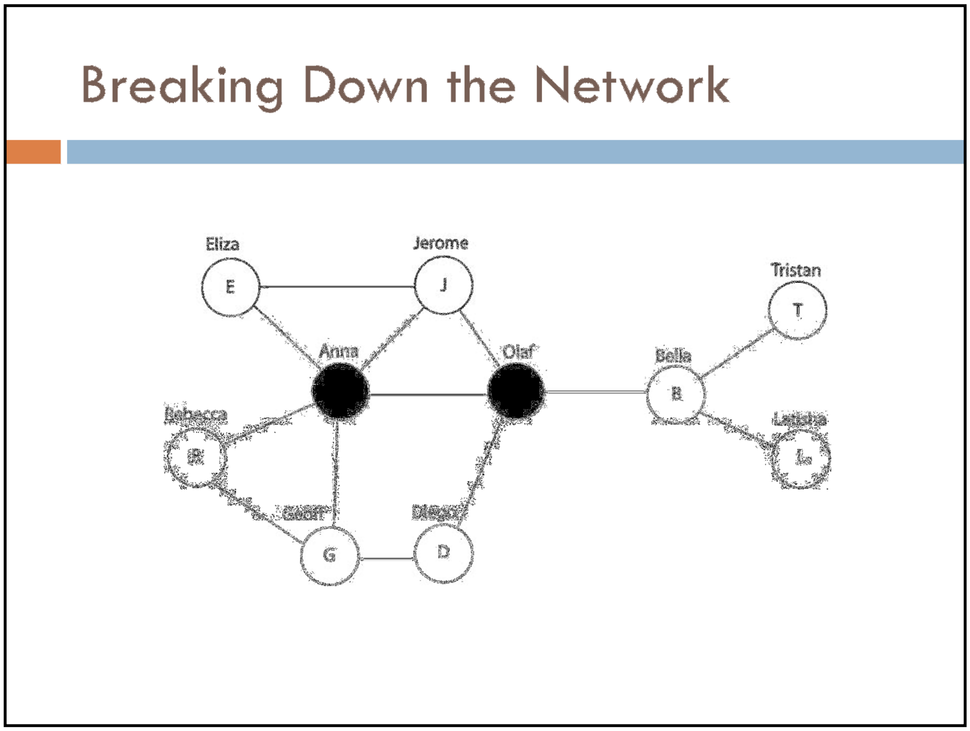
Within the same graph, if there is no edge between two nodes, there is either no direct relationship or a direct relationship is not known to exist.

This is what is meant by "connecting the dots." The intelligence agencies had shared the information on Abdul Mutallab, but they failed to draw the edges that would connect him to the terrorist network, at least not in time to do something about it.

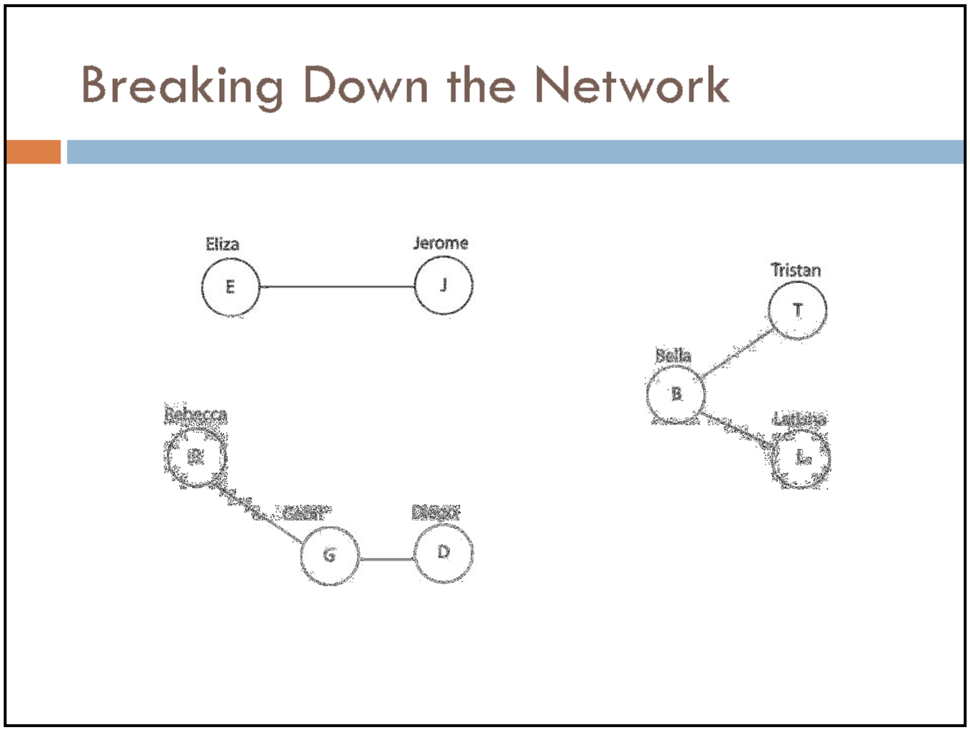
If someone has connections to a terrorist network, officials know to watch them.

But this is not all intelligence agencies do.

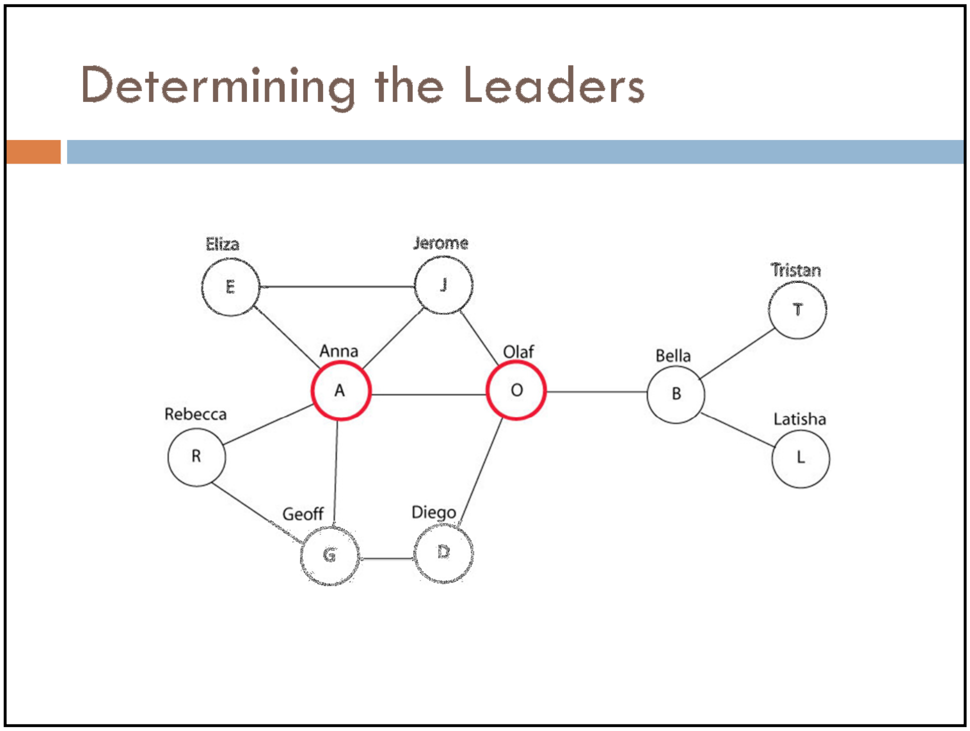
Constructing the network and placing people on watch-lists and no-fly lists is only the beginning. Intelligence agencies actively pursue these networks and try to stop them at their core.



Their main objective is to find the facilitators and communication go-betweens such as Anna and Olaf in this graph. If the leaders are discovered and stopped…



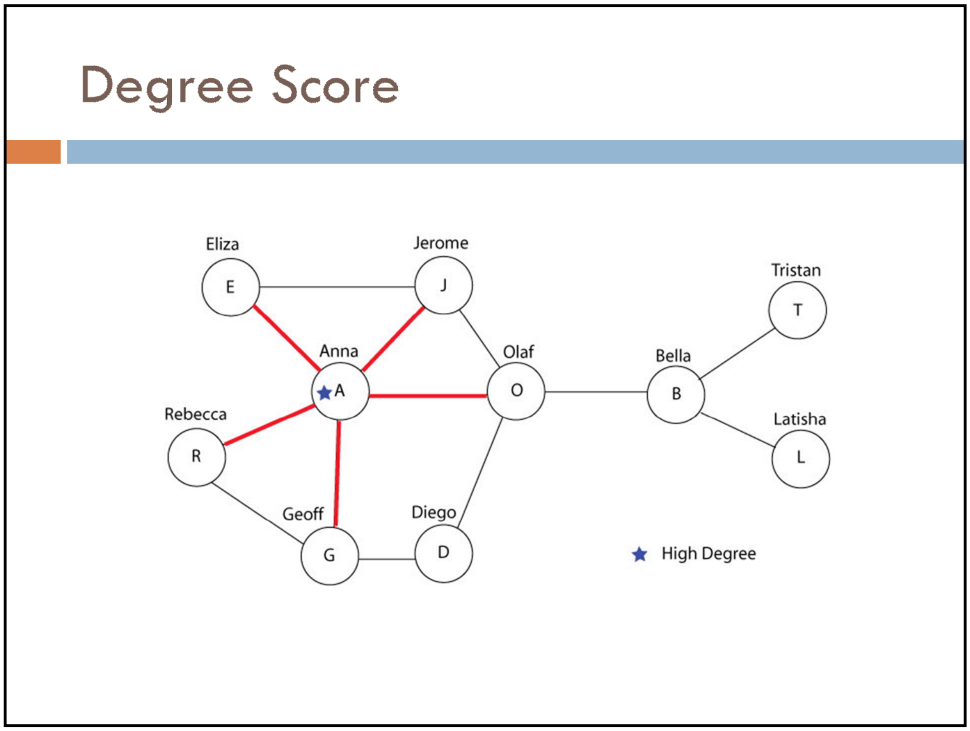
…the entire network breaks down. You can think of it as "killing several 'birds' with one stone."



You can tell by simply looking at this graph that Anna and Olaf are significant players in the network. But this graph was constructed after Anna's and Olaf's significance was known. So how does the NCTC analyze a terrorist network to determine the leaders?

Three Scores of Leadership

- Degree Score
- Betweeness Score
- Closeness Score

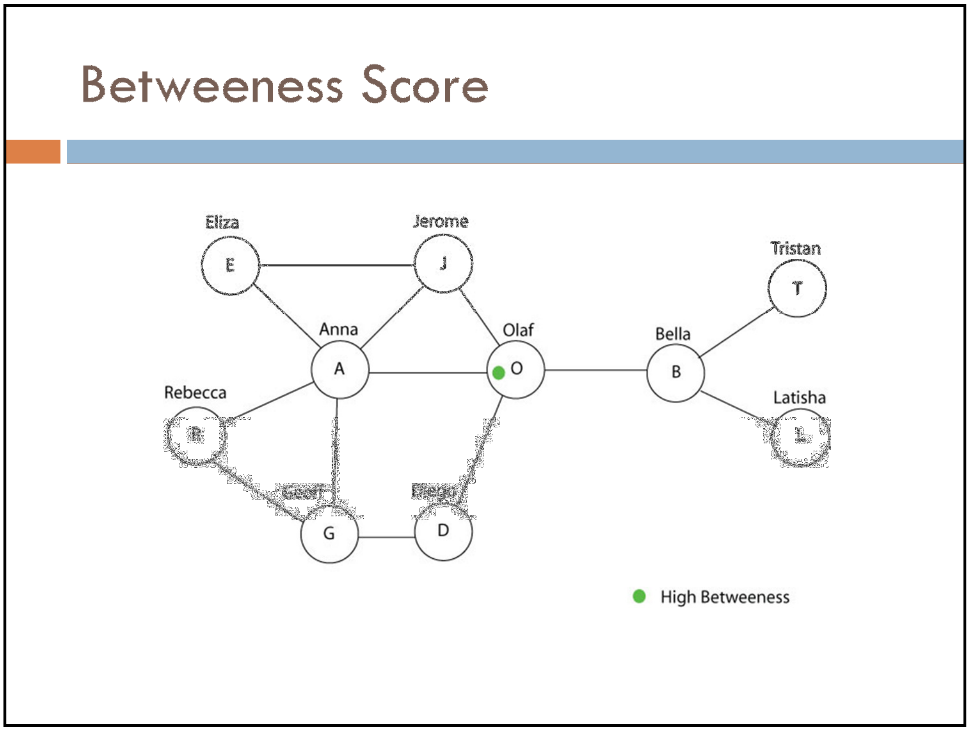


The degree score rates the node based on the number of nodes directly connected to it.

Anna has degree 5 while all others have degree 1, 2, 3, or 4. Olaf could be considered to have a high degree as well.

Nodes with High Degree

- Well-connected
- Active players in the network
- Often connectors or hubs in the network
- Identified as being deal makers
- Have advantaged positions
- Are not necessarily the most powerful people in the network



The betweeness score rates the node based on its role as a 'stepping stone' along geodesic paths between other pairs of nodes.

Betweeness = #geodesic paths through node/#geodesic paths

A node with high a betweeness score connects sets of nodes that have few or no other connections.

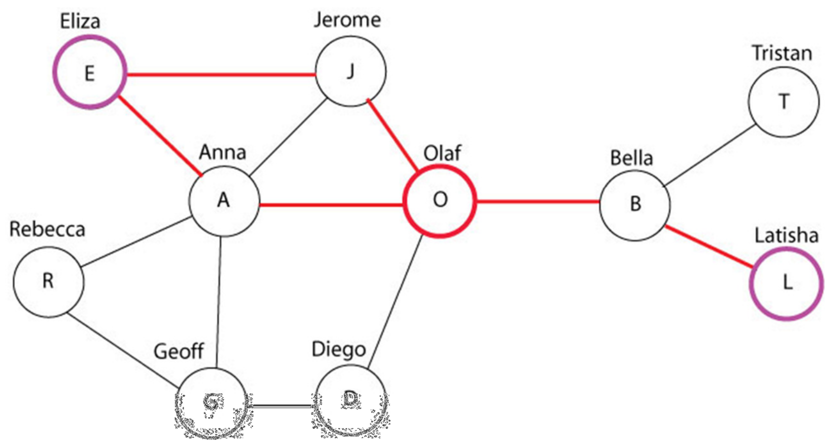
For example, there is a geodesic path from Eliza to Latisha that passes through Olaf, so Olaf gains potential importance within the network.

To calculate the betweeness score of Olaf with respect to Eliza and Latisha, we first need to find all geodesic paths from Eliza to Latisha.

The geodesic path is distance 4, so we will disregard paths greater than 4.

Betweeness of Olaf with Respect to Eliza and Latisha

- Geodesic Distance: d(E,L) = 4



Geodesic paths:

EJOBL

EAOBL

Paths through Olaf:

EJOBL

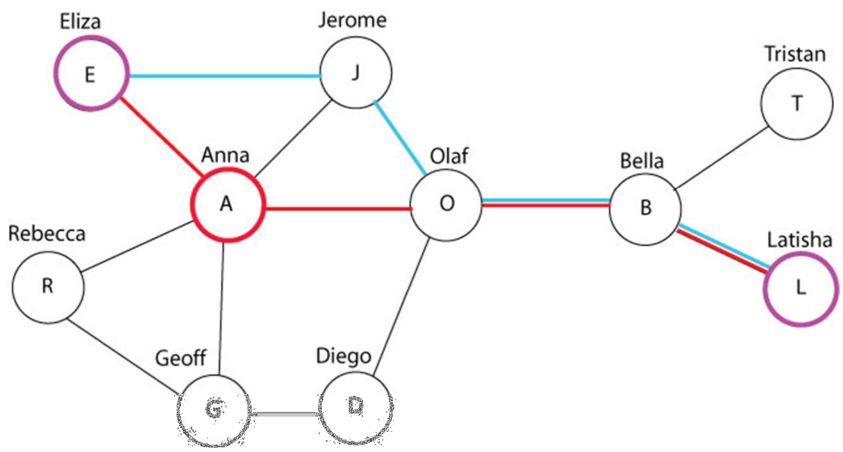
EAOBL

Betweeness of Olaf with Respect to Eliza and Latisha

- Betweeness = #geodesic paths through node/total #geodesic paths
  - Geodesic paths from Eliza to Latisha:
    EJOBL and EAOBL
  - Geodesic paths from Eliza to Latisha through Olaf:
    EJOBL and EAOBL
- Olaf's betweeness score with respect to Eliza and Latisha is 1.

Betweeness of Anna with Respect to Eliza and Latisha

- Geodesic Distance: d(E,L) = 4



Geodesic paths:

EJOBL

EAOBL

Paths through Olaf:

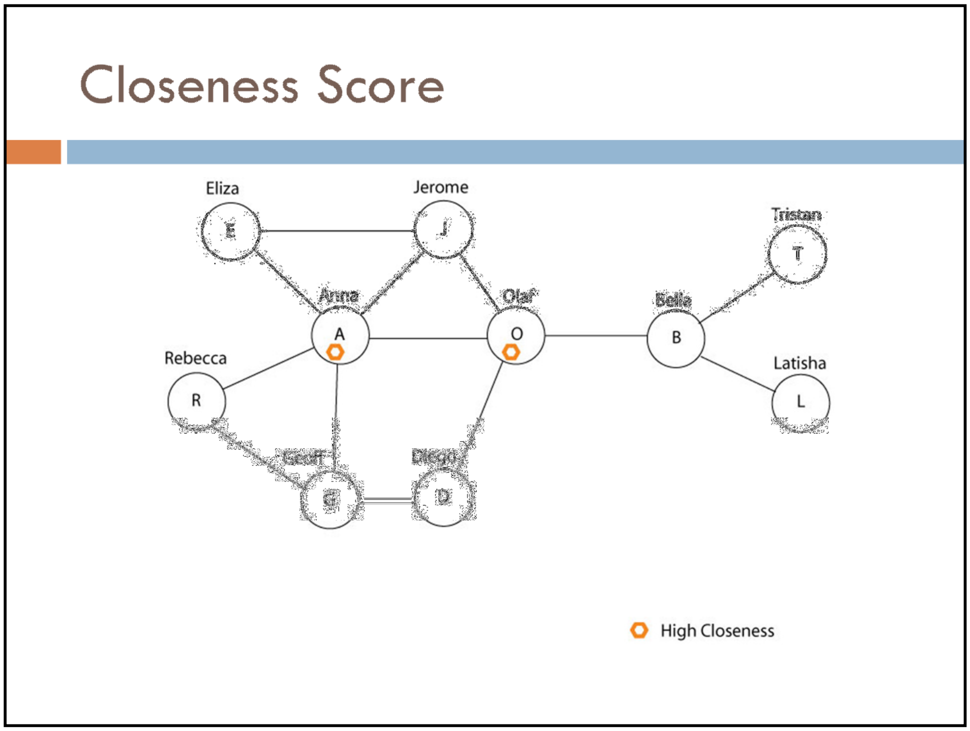
EAOBL

Betweeness of Anna with Respect to Eliza and Latisha

- Betweeness = #geodesic paths through node/total #geodesic paths
  - Geodesic paths from Eliza to Latisha: EJOBL and EAOBL
  - Geodesic paths from Eliza to Latisha through Anna: EAOBL
- Anna's betweeness score with respect to Eliza and Latisha is 1/2.

Nodes with High Betweeness

- Hold a favored or powerful position within the network
- Represent a single point of failure (take this person out of the network and the ties between cliques are severed)
- Have a greater amount of influence over what happens in a network



The closeness score rates the node based on how close it is to all other nodes in the network.

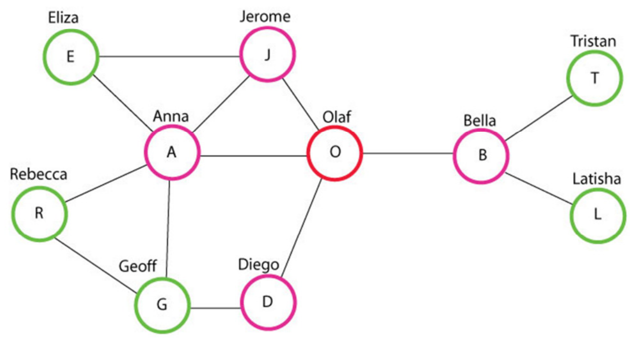
While degree accounts for only direct connections, closeness gives credit for having many connections at distance 2 and 3 and even more.

A node with a high closeness score has short paths to all other nodes in the network.

To calculate the closeness score, first calculate the distance from the node in question to each other node in the network.

Closeness of Olaf

- d(O,B) = 1
- d(O,T) = 2
- d(O,L) = 2
- d(O,A) = 1
- d(O,J) = 1
- d(O,D) = 1
- d(O,G) = 2
- d(O,E) = 2
- d(O,R) = 2

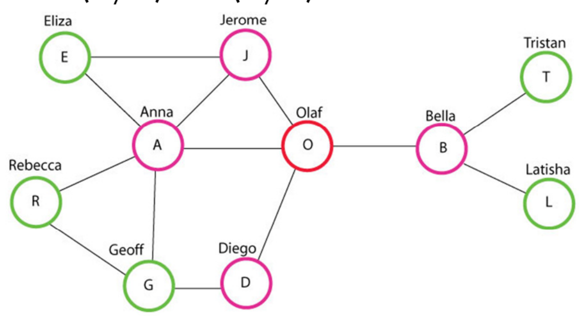


Then sum the reciprocals. The smaller the distances, the larger the reciprocals.

Closeness of Olaf

- d(O,B) = 1
- d(O,T) = 2
- d(O,L) = 2
- d(O,A) = 1
- d(O,J) = 1
- d(O,D) = 1
- d(O,G) = 2
- d(O,E) = 2
- d(O,R) = 2

- Sum the reciprocals:
  - 1/1 + 1/2 + 1/2 + 1/1 + 1/1 + 1/1 + 1/2 + 1/2 + 1/2
  - Olaf's closeness score is 6.5.
- 4(1/1) + 5(1/2)

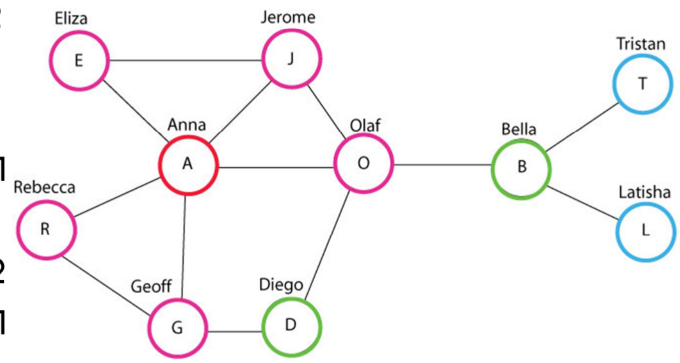


Same as 3 nodes at distance 1 plus 5 nodes at distance 2

Anna looks fairly close to other nodes as well.

Closeness of Anna

- d(A,B) = 2
- d(A,T) = 3
- d(A,L) = 3
- d(A,O) = 1
- d(A,J) = 1
- d(A,D) = 2
- d(A,G) = 1
- d(A,E) = 1
- d(A,R) = 1

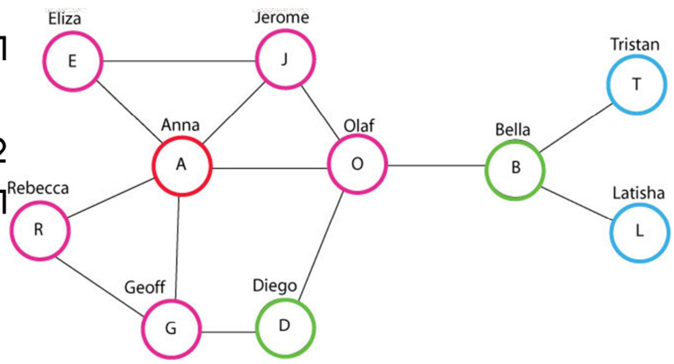


Then sum the reciprocals. The smaller the distances, the larger the reciprocals.

Closeness of Anna

- d(A,B) = 2
- d(A,T) = 3
- d(A,L) = 3
- d(A,O) = 1
- d(A,J) = 1
- d(A,D) = 2
- d(A,G) = 1
- d(A,E) = 1
- d(A,R) = 1

- 5(1/1) + 2(1/2) + 2(1/3)
- Anna's closeness score is 6.66.



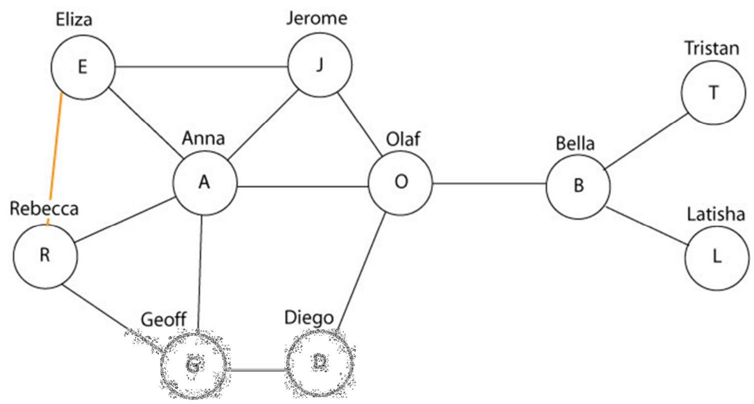
Same as 3 nodes at distance 1 plus 5 nodes at distance 2

Nodes with High Closeness

- Have quick access to other nodes in the network
- Have a high visibility to what is going on in the network

Connection Probability

- Estimate which edges are missing
- Combine with other information to find key nodes



•Estimate which edges are missing based on available information
•Combined with other information to enhance likelihood of determining key nodes

If Anna and Eliza have a relationship and Anna and Rebecca have a relationship, it is likely that Eliza and Rebecca have the same or similar relationship.

Successfully Connecting the Dots

- June 7, 2006: Abu Musab al-Zarqawi was killed by bombs dropped by American F-16 fighter jets.
- The key to this mission was identifying and focusing on a node of distance 1 from the most important target.

Abu Musab al-Zarqawi was the leader of Al Qaeda in Iraq and the most-wanted terrorist in that war zone.

He led a vicious terrorist campaign including the capture and televised beheadings of American civilians working in Iraq.

Through an extensive intelligence effort, Sheik Abdul Rahman, al-Zarqawi's "spiritual advisor," was monitored and ultimately provided the critical link to finding al-Zarqawi.

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