Searching for Technosignatures through Network Analysis

Technosignatures Amenable to Network Analysis
Waste heat, artificial illumination, artificial atmospheric constituents, artificial surface constituents, stellar pollution, non-terrestrial artifacts, and megastructures, in addition to electromagnetic transmissions.

Network Node
A node represents an exoplanet's host star (host star as effective proxy for an exoplanet in question when modeling a network on an interstellar scale; the analysis currently under development focuses on nodes on an interstellar scale, instead of intra-stellar or within a solar system).

Network Edge
An edge represents a hypothetical navigation or communication pathway between exoplanets or exoplanet systems.

Network Fitting: Single Fitted Component Network
A single fitted component network is a type of network fitting. It is manifested by applying a fitness function to nodes and edges such that the resulting graph/network has a single component (no partitions).

For this analysis, the fitness of edges between exoplanet host stars is based on a hypothetical "max distance" for navigation or communication. It serves as a filter to approximate natural network topologies between exoplanet host stars; topologies that model navigation or communication relay pathways similar to what emerges in Earth-based social, business, and computer networks.

"Max distance" should not be confused with being a radius of a network; it is not a radial distance from a network center point to its outer most edge. Also, edges are not necessarily drawn from every host star to every other host star in a sample of exoplanets (a sample typically using data from the NASA Exoplanet Archive). "Max distance" is simply the maximum edge length allowed in the network.

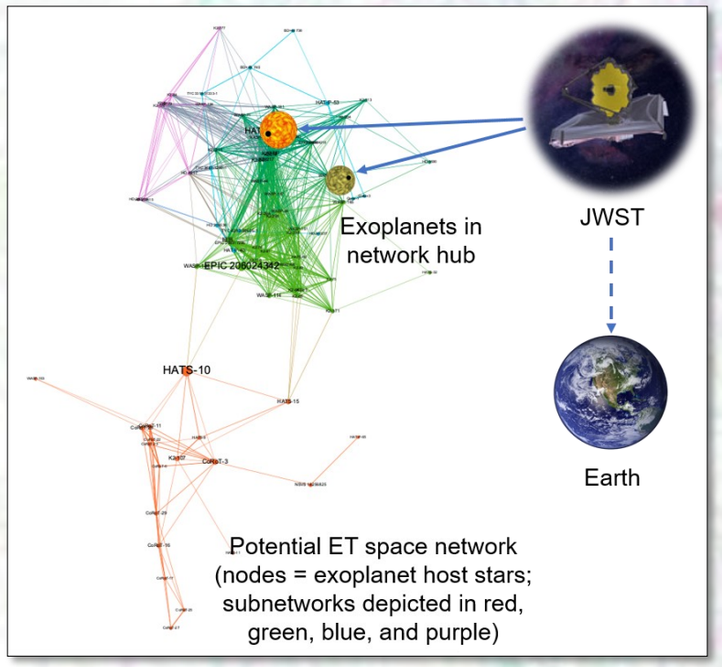

Figure 1. Example of possible network analysis using the upcoming James Webb Space Telescope (JWST), using the following process:

1. Use network analysis to find hubs of potential ET space networks.
2. Then locate an exoplanet of interest (e.g., a habitable zone exoplanet or other) in or near a network hub.
3. Then search for a technosignature (e.g., waste heat, megastructure, or other) in or near the aforementioned exoplanet using observational data from the JWST.

Note: Network analysis can be combined with other search methods to triangulate in on locations of potential technosignatures.

Software
A custom algorithm would be implemented in a Python software program (known as a point processing toolkit or "pptk" package for visualizing 2D and 3D points). The algorithm applies an iterative fitness function with a series of increasing "max distances" between a sample of exoplanet host stars, and uses the minimum of these max distances to get a network with a single component.

Algorithms such as HITS, Eigenvector Centrality, Betweenness Centrality, or PageRank are then used to identify exoplanets/host stars that are key "hubs" or "brokers" in the pathways of the network.

Potential Contributions to the Field

- Improved accuracy in finding technosignatures for project or mission design, and for operationalizing models such as the Drake Equation.
- Greater accuracy in reaching a Schelling Point (mutual realization of how we and ET can find each other).
- Promoting interdisciplinary research, incorporating or advancing knowledge of various scientific fields.

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