

Hidden Maps

A Plain-Language Introduction to the Network Analysis Series

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1 Start Here

You do not need an engineering degree to read this series. You do not need to know what an eigenvector is, or what “scale-free” means, or why anyone would draw a graph without axes.

You already understand networks. You have been stuck behind someone who could not merge. You have watched a storm in Atlanta delay a flight in Portland. You have taken the long way home because one intersection was closed. What you may not have had is a name for the pattern — or a way to compare a flight map, a power line, and a city street on the same terms.

That is what this series does. Four episodes, four hidden maps, one shared way of looking at them. This page is the map to the maps.

Reading order: Ep. 0 (this page) → Ep. 1 Flights → Ep. 2 Grid → Ep. 3 Streets → Ep. 4 Internet.

2 The One Idea Behind Every Episode

Every system in this series can be drawn the same way:

- **Dots** — the places or things (airports, substations, intersections)
- **Lines** — the connections between them (routes, transmission lines, streets)

That picture is the **network**. The rest of the series asks variations of the same three questions:

1. **Who is important?** Not “who is busiest in normal times,” but who carries traffic *because of where they sit* in the structure.
2. **Is the system clustered or spread out?** Do connections bunch into local neighborhoods, or is everything evenly mixed?
3. **What happens when things break?** Does the system shrug off random bad luck — or fall apart when the *right* dot is removed?

Those three questions sound abstract until you attach them to something you have lived through.

Everyday experience	What the network view calls it
A delay in Atlanta reaches Pittsburgh	A hub concentrates connections
One substation failure triggers a wide blackout	A chokepoint sits on too many paths
Closing one bridge strands half the city	Targeted removal hurts more than random closure
Most side-street closures barely matter	Random failure is survivable when hubs are rare

The technical papers use precise vocabulary. This introduction gives you the vocabulary. The papers give you the measurements.

3 Four Words Worth Knowing

You will see these in every study. Each has a plain-English meaning.

3.1 Hub (degree)

A **hub** is a dot with many lines attached. Atlanta has many flight routes. A major substation may connect to many transmission lines. A downtown intersection may meet six or eight streets.

Hubs are obvious on a map. They are not always the most dangerous points to lose — but they are always worth noticing.

3.2 Chokepoint (betweenness)

A **chokepoint** is a dot that sits on a disproportionate share of *through traffic* — not traffic that starts or ends there, but traffic that must pass through to get somewhere else.

Imagine the only bridge across a river. It may not be the largest intersection in the city, but everyone crossing the river must use it. In the studies, this idea is called **betweenness centrality**. You can read it as: *if we close this one place, how many trips suddenly get longer or impossible?*

A hub and a chokepoint can be the same dot. Often they are not.

3.3 Small-world structure

Many real networks — including every episode in this series — are **small-world**: your neighbors are tightly connected to each other, but you can still reach the far side of the system in surprisingly few hops.

Think of air travel: airlines cluster routes regionally, yet almost any two US airports are only a connection or two apart. Or friendships: your friends know each other, but you are still only a few introductions from a stranger.

The papers quantify this with a number called sigma. You do not need the formula. You only need the intuition: **locally clustered, globally short**. That combination is everywhere in infrastructure.

3.4 Random failure vs. targeted attack

Every study runs the same thought experiment:

- **Random failure**: close dots in random order — like bad weather closing random small airports, or scattered road work.
- **Targeted attack**: close the most important dots first — like deliberately shutting hub airports or the highest-betweenness intersections.

Almost every real network tolerates random failure far better than targeted attack. Random closure rarely hits a chokepoint. Targeted closure always does. The gap between those two curves is the series' central visual result.

4 The Episodes — What Each One Is Really About

Read in order if you are learning the theory alongside the results.

4.1 Ep. 1 · Flights — [The Architecture of Flight](#)

The hidden map: America's domestic flight routes.

The lived experience: A delay in one hub city ripples nationwide.

What it measures: Roughly 500 US airports and the routes between them (OpenFlights data). The network is hub-and-spoke — a handful of cities concentrate routes because airlines profit from feeding connections through them.

The punchline: Random airport closures are survivable for a surprisingly long time. Closing the most central airports fragments the country fast. The flight you almost made was delayed by topology, not bad luck alone.

[Read the study →](#)

4.2 Ep. 2 · The Grid — [When the Lights Go Out](#)

The hidden map: A synthetic US transmission grid — 2,000 substations and the high-voltage lines linking them.

The lived experience: Blackouts that seem to come from one failure somewhere you have never heard of.

What it measures: A publicly available engineering case file that statistically matches real US grid structure (the real topology is restricted for security). Substations are dots; transmission lines are edges.

The punchline: The grid is strongly small-world and moderately heterogeneous — engineered, not accidentally scale-free. A few buses carry a huge fraction of shortest paths. The same random-vs-targeted asymmetry appears: the grid absorbs scattered failures better than the loss of its structural bottlenecks.

[Read the study →](#)

4.3 Ep. 3 · Streets — [The Intersections That Hold a City](#)

The hidden map: Pittsburgh’s driveable streets — about 9,000 intersections and 13,000 segments (OpenStreetMap via OSMnx).

The lived experience: One closure ruins everyone’s commute; twenty random closures might not.

What it measures: The primal street graph — intersections as dots, street segments as lines. Rivers and bridges elevate chokepoints you already know by frustration.

The punchline: Pittsburgh’s street network is small-world and robust-yet-fragile in the same way as the sky and the grid. Geography writes itself into betweenness: the dots that matter are often the bridges and downtown distributors, not the noisiest traffic intersections.

[Read the study →](#)

4.4 Ep. 4 · Internet — [The Handoff Behind Your Click](#)

The hidden map: Autonomous Systems — the independent networks that hand off your traffic (CAIDA BGP snapshot).

The lived experience: A Cloudflare outage, a cable cut, a peering dispute — the internet “feels” decentralized but routes through a small set of transit backbones.

What it measures: Tens of thousands of ASes and their business relationships. Community detection finds routing neighborhoods; betweenness finds the plumbing.

The punchline: Same robust-yet-fragile curve at planetary scale. Random small-network outages barely matter; removing chokepoint ASes fragments reachability fast.

[Read the study](#) →

5 What All Four Episodes Have in Common

After reading the studies, you should be able to finish these sentences:

1. **Each system has a few load-bearing dots** that are not obvious from daily use alone.
2. **Random bad luck is not the same as hitting the right dot** — and the difference is visible on a curve, not just in stories.
3. **Geography and engineering shape the hidden map** — rivers, voltage levels, and airline economics leave fingerprints.
4. **The same toolkit applies** — dots, lines, hubs, chokepoints, random vs. targeted — whether the system moves electrons, aircraft, or cars.

That toolkit is network analysis. The series does not ask you to master the math behind it. It asks you to recognize the pattern when you see it next — in a supply chain, a social media graph, a food web, or the internet backbone.

6 What You Can Ignore (Unless You Want It)

Each technical paper includes sections you can skip on a first read:

- **Degree distribution / power-law fits** — statistical detail about how unequal the hub structure is. The plain-English version is always: *a few dots have many more connections than the rest.*
- **Sigma and clustering formulas** — the proof that the network is small-world. The plain-English version is: *locally bunched, globally short.*
- **Python code blocks** — they generate the figures; they are not part of the narrative.

Read the introductions, look at the maps and robustness curves, skim the discussion. That is a complete reading.

7 Coming Next in Hidden Maps

Future episodes may include biological and knowledge networks — the *C. elegans* connectome (302 neurons), a food web, or a patent citation graph. Same toolkit, new hidden maps.

8 A Note on Why These Objects

This series follows the site's broader instinct — borrowed from writers like Mark Kurlansky — that the dullest subjects often run the world. Salt preserved empires. Cod fed nations. The zipper, the pencil, and the flight you almost made are not glamorous until you look closely.

Networks are the looking-closely tool. They do not replace engineering analysis, economic history, or policy debate. They add a structural lens: *before we argue about what to do, let us agree on the shape of the thing.*

If these three studies change how you see one delay, one blackout, or one detour, they have done their job.

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