This is a fascinating research intersection. Combining **Community Detection** (a core method in Social Network Analysis) with **Road Networks** usually moves the analysis from "static physical infrastructure" to "dynamic functional zones."

In this context, "communities" are often not people who know each other, but **clusters of locations that interact heavily** (via traffic flow, taxi rides, or commuter patterns).

Here are key research papers and topics categorized by how they apply SNA techniques to road networks.

1. Functional Urban Regions (Mobility as "Social" Ties)

These papers treat locations as "nodes" and trips (taxis, commuters) as "edges." If two areas exchange a lot of people, they form a community, revealing the "true" borders of a city regardless of administrative lines.

- **Paper: "Identifying functional urban regions within traffic flow" (2014)**
    - **Authors:** Brittney O'Sullivan, et al.
    - **Core Concept:** This is a foundational text for your topic. They constructed a network from 1.5 million minicab journeys in London.
    - **SNA Application:** They applied the **Louvain Method** (a classic social community detection algorithm) to the traffic graph.
    - **Finding:** The "communities" detected perfectly mapped onto known social and functional neighborhoods (e.g., "The West End" or "The City") purely from car movements, without using any zip code or map data.
- **Paper: "Hierarchical community detection and functional area identification with OSM roads and complex graph theory" (2019)**
    - **Authors:** Zhong, et al.
    - **Core Concept:** Uses OpenStreetMap (OSM) data combined with Points of Interest (POI).
    - **SNA Application:** They used the **Infomap algorithm** (which uses the probability of flow to find communities).
    - **Finding:** They found that road networks have a hierarchical structure similar to social groups (e.g., small local streets $\rightarrow$ arterial roads $\rightarrow$ highways) and used this to automatically identify functional zones like "residential" or "commercial" districts.

2. Vehicular Social Networks (VSN)

These papers look at the actual "social" layer on top of roads—where vehicles (and their drivers) are the nodes interacting via communication protocols (VANETs).

- **Paper: "Overlapping Community Detection in Vehicular Social Networks Based on Graph Attention Autoencoder" (2025)**
    - **Context:** Very recent work.
    - **Core Concept:** Vehicles are nodes that have "social attributes" (driver preferences, destination) and "physical attributes" (location on the road).
    - **SNA Application:** Traditional algorithms (like Girvan-Newman) fail here because vehicles move fast. This paper uses a **Graph Attention Network**

(GAT) to find overlapping communities where a vehicle might belong to a "geographic community" and a "driver interest community" simultaneously.

3. Congestion & Resilience Clusters

Here, "communities" are pockets of congestion. If Road A gets jammed, Road B usually does too. They are "friends" in a misery network.

- **Paper: "Community detection in large scale congested urban road networks" (2021)**
    - **Authors:** Haghbayan, et al.
    - **Core Concept:** Managing traffic by splitting a city into zones (perimeter control).
    - **SNA Application:** They used **Infomap** and **Modularity Maximization** to group road segments that have similar density patterns.
    - **Finding:** Instead of controlling traffic explicitly by district, it is more efficient to control it by "congestion communities"—groups of roads that behave identically during rush hour.

Summary of Algorithms Used

If you are writing a literature review, note that these SNA algorithms are the most common in your specific domain:

Algorithm	**Why it's used in Road Networks**
Louvain Method	Best for finding "functional regions" (e.g., where people live vs. work) because it maximizes internal density of trips.
Infomap	Best for "flow" analysis. It models a random walker (a car) moving through the network, identifying traps where traffic gets stuck.
Girvan-Newman	Rarely used for large road networks because it is computationally too slow ($O(n^3)$), but often cited in older theoretical papers.
Spectral Clustering	Used when analyzing the "resilience" of a road grid (cutting the graph into pieces to see which roads are critical).

Relevance to your Research

For your topic, you should decide if you are studying:

1. **The Road Structure itself:** (e.g., "Which intersections form a cluster?")

2. **The Flow on the Road:** (e.g., "How do taxi movements create invisible neighborhoods?")

The video below explains **Hierarchical Community Detection**, which is critical for road networks because roads naturally have a hierarchy (Highway $\rightarrow$ Street $\rightarrow$ Lane) similar to social hierarchies.