Synergistic Traffic Data Analytics: Toward Mapping Vehicle Weights on All U.S. Roadways

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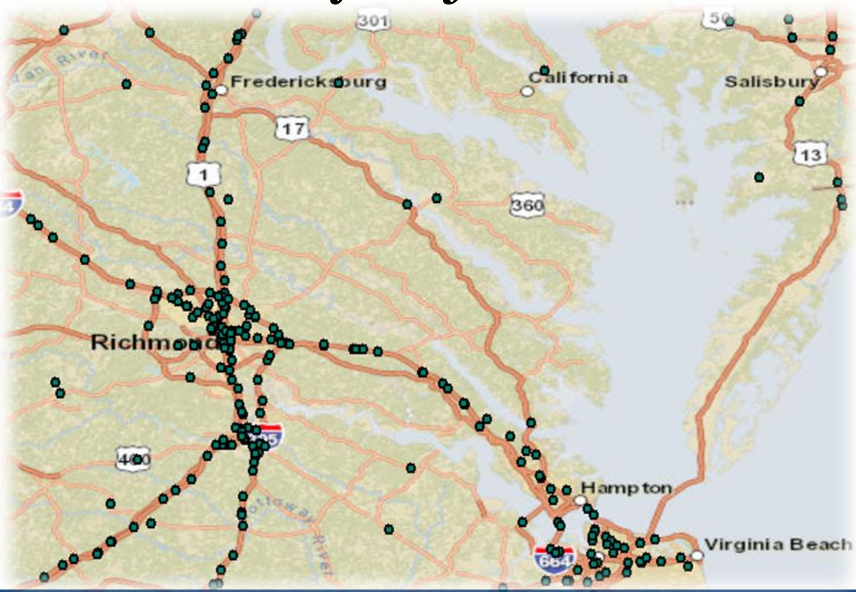
Goal of Research

- Develop a methodology to extrapolate truck travel weight data to locations for which such data is ***not*** available.
- Our key goal was to develop a method that:
  1) has as few assumptions as possible and
  2) is as much driven by objective data as possible.



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Two Key Assumptions

1. There is vehicular flow conservation as in the synergistic traffic counting technique (Ng, 2012).
2. The average weight of a vehicle belonging to a given vehicle class is the same throughout a certain region (such as country, state etc).
   - For example, average weight of a Class 9 truck is, on average, the same whether this is a Class 9 truck is in Texas or Virginia, or any other location.

Reference

Ng, M.W. (2012) "Generalizing FHWA's Ramp Counting Procedure for Arbitrary Network Topologies: Some Examples of How to Count More with Less.“ *Transportation Research Board 91st Annual Meeting*. No. 12-1228.

What It Requires: Input

- **All input data for the proposed methodology is readily available:**
  - The road network topology under consideration.
  - The locations of volume and classification stations, and their recorded values.
  - Other locations where count and/ or classification data are available and their recorded values, e.g. ramp counts.
  - The average weight per vehicle class.

What It Delivers: Output

- The **output** of the method gives **lower and upper bounds on the average daily weight carried by a road segment.**
  - That is, the output will state that the average daily weight carried by a road segment is **at least** x tons, and **at most** y tons.
- Depending on the location of the road segment, the locations of volume and classification sensors and the road network topology, the lower and upper bounds might lie farther from or closer to each other.

Illustrative Example

Suppose ramp count on link 3 known (500 veh/ day, say)

Suppose link 5 has a class site

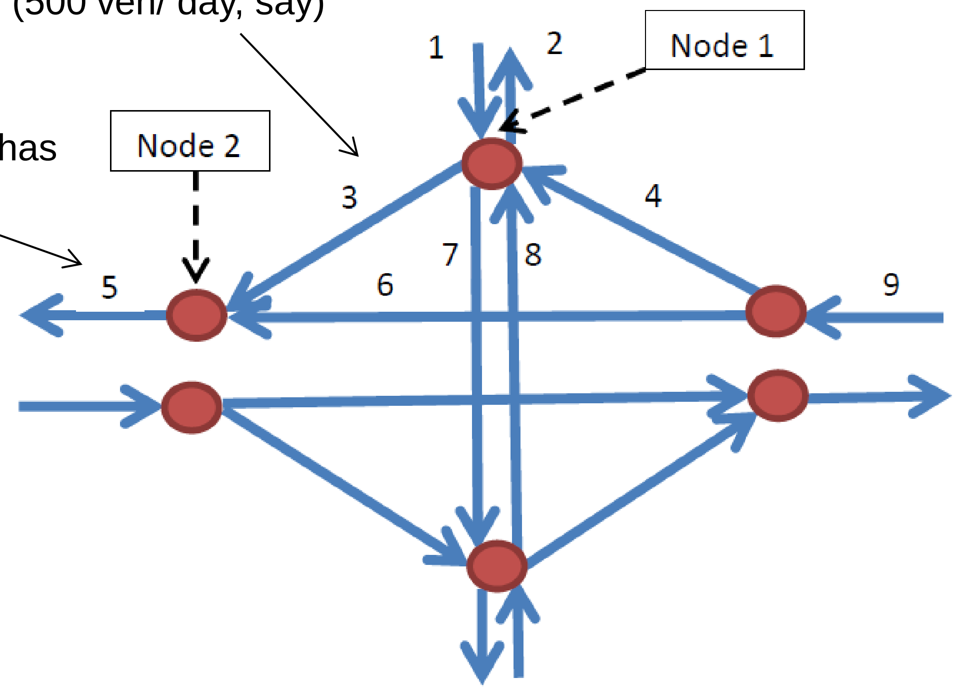

Figure 1: Diamond Interchange

Vehicle Class	Weight (metric tons)	AADT Link 5
1	0.150	0
2	2	30
3	3	2500
4	9.31	50
5	7.015	100
6	11.515	20
7	26.682	0
8	12.906	20
9	20.294	200
10	37.202	50
11	16.865	0
12	25.464	0
13	54.000	0

Question: What can we say about the average daily tonnage on link 6?

Answer

- **Answer:** The average daily tonnage carried by link 6 must lie **between 7380 tons and 13664 tons**.

- Why?

- For this small example, it is relatively easy to understand why these are the logical values, as we shall demonstrate next.

Solution: Lower Bound

- Easy to verify that AADT on link 5 is 2970 vehicles per day.
- Since the volume on link 3 is 500 per day, the total volume on link 6 must be equal to 2970 – 500 = 2470 vehicles per day.

Vehicle Class	Weight (metric tons)	AADT Link 5
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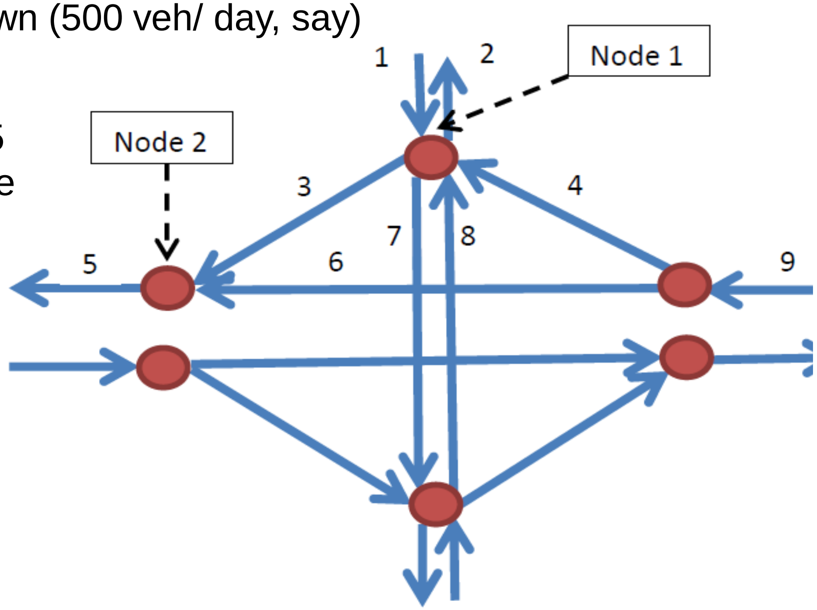

Figure 1: Diamond Interchange

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Solution: Lower Bound

- To determine the lowest possible tonnage carried by link 6, one would assume that these 2470 vehicles are "as light as possible". **Agree?**
- From the table, it can be seen that vehicles of class 1 are the lightest. Can we assume that these 2470 vehicles are of class 1?
- We cannot: no such vehicles have used link 5. That is, no such vehicles could have passed through link 6 as well.
- The second lightest vehicle class is vehicle class 2, with an average weight of 2 tons per vehicle. To find the smallest possible tonnage carried by link 6, can we assume that **all 2470 vehicles on link 6** belong to class 2 then?

Solution: Lower Bound

- The answer is again no since only 30 vehicles recorded on link 5 belong to vehicle class 2. **But, it is consistent** to say that **at most 30 of the 2470 vehicles on link 6 are of class 2**.
- Since the goal is to find the lowest possible tonnage on link 6, it is then assumed that there are 30 vehicles of class 2 that use link 6, contributing to 30 x 2 tons = 60 tons to the total tonnage on link 6.
- Next we proceed to assign the remainder of the 2470 – 30 = 2440 vehicles.

Solution: Lower Bound

- The next lightest vehicle class is class 3, with an average weight of 3 tons. The table shows that up to 2500 vehicles of class 3 pass through link 5 on a given day.
- Since there is no evidence to contradict that the remaining 2440 vehicles on link 6 are all of class 3, to find the lowest possible tonnage on link 6, such an assumption can be justified.
- The tonnage on link 6 contributed by these class 3 vehicles would then be 2440 x 3 tons = 7320 tons.

	# vehicles	Weight (tons)	Total Weight (tons)
Class 2	30	2	60
Class 3	2440	3	7320
Total	2470		7380

Solution: Upper Bound

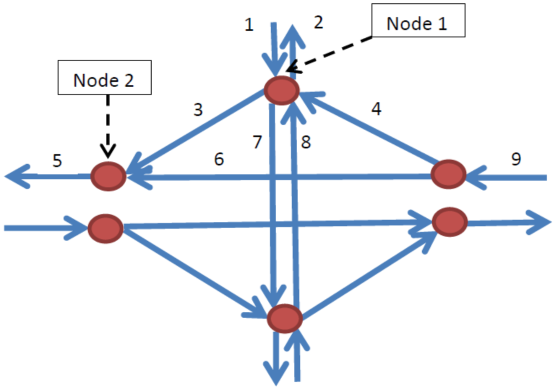

Figure 1: Diamond Interchange

- Similarly, one can determine the maximum daily tonnage carried by link 6
- The 2470 vehicles are now assigned to the heaviest vehicle classes first, in order to maximize the tonnage carried on link 6.
- Result:

	# vehicles	Weight (tons)	Total Weight (tons)
Class 10	50	37.202	1860.1
Class 9	200	20.294	4058.8
Class 8	20	12.906	258.12
Class 6	20	11.515	230.3
Class 4	50	9.31	465.5
Class 5	100	7.015	701.5
Class 3	2030	3	6090
Total	2470		13664

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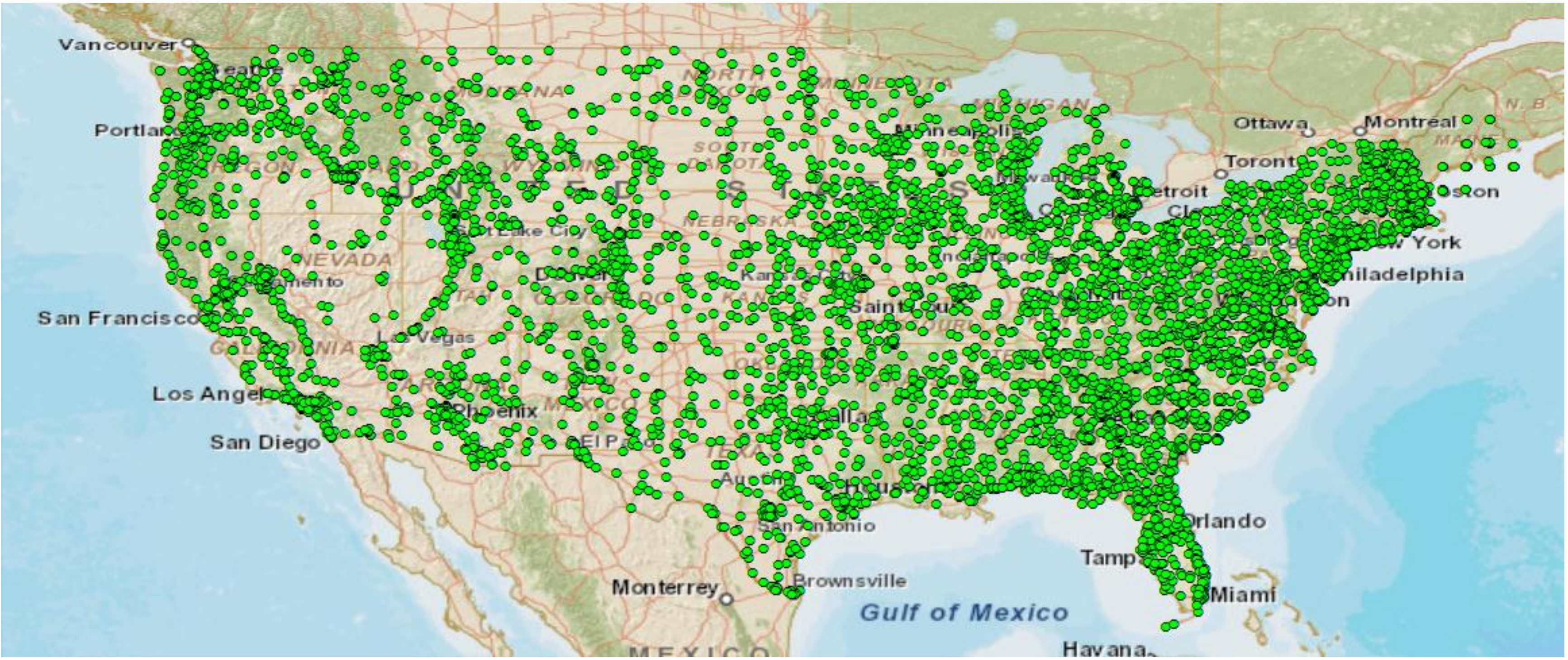
Possible to do the same at a larger scale



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Large Road Networks

- Only for small road networks is it possible to manually determine the lower and upper bounds on the tonnage carried by a road segment.

- For large networks, solve a complex looking linear optimization problem.

- **Luckily:** Many standard software packages available for this type of problems, e.g. **Microsoft Excel.**

Concluding Remarks

- Keep in mind: ***Prior to this method**, **nothing objective can be said about the tonnage carried by road segments on which no WIM and classification sites were available.***
- With some modifications, methodology gives **free by-products**: lower and upper bounds on **traffic volumes**, lower and upper bounds on **volumes by class**.
- Can be used to guide where to install new sensors for "maximum benefit". (i.e. to build synergy among sensors.)

Feedback Always Welcome

- Please email me at mng@odu.edu or call 757 683 6665 if you have any questions or comments.