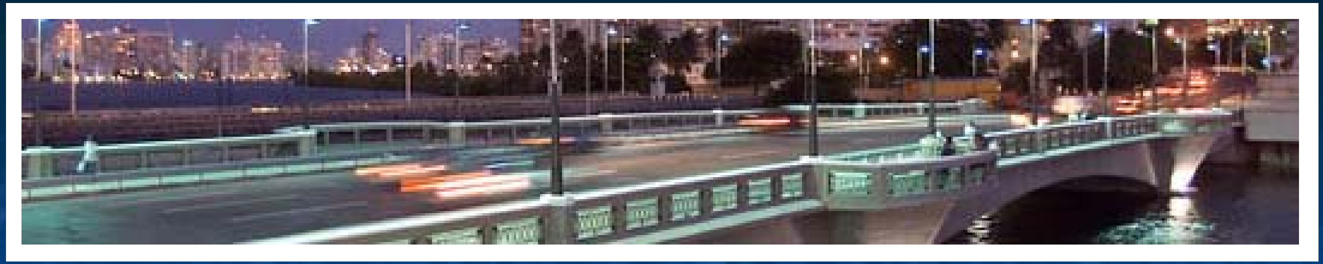
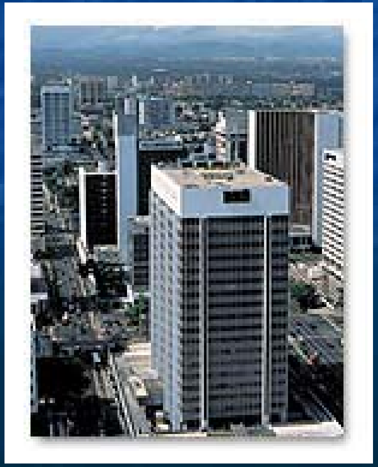


Multiclass, Multicriteria TNE Model to improve transit activity in San Juan Metropolitan Area



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Project Goals

- Highlight the importance of Multiclass, Multicriteria Network Equilibrium Models
- Describe the Multiclass, Multicriteria TNE Model developed by Nagurney & Dong (2000)
- Describe current and proposed traffic network in the San Juan Metropolitan Area
- Discuss how to apply the model to study this particular network

Multiclass, Multicriteria TNE Models

- Allow weighting decision-making criteria
- Travelers consider several criteria to choose their optimal travel path $\rightarrow$ Quandt (1967)
- Uncongested model $\rightarrow$ Dial (1979)
- Congested model, infinite-dimentional VI formulation of multiclass, multicriteria TNE problems, qualitative properties $\rightarrow$ Dafermos (1981)

Multiclass, Multicriteria TNE Model
(Nagurney & Dong 2000)

- Allow weighting decision-making criteria which are class and link dependent
  - travel time and travel cost
- Deals with demand functions that are not separable
- Qualitative analysis
- Computational procedures (VI)

Multiclass, Multicriteria TNE Model
(Nagurney & Dong 2000)

- k = classes of travelers in the network with a class denoted by i
- f_{ai} = flow of class i on link a
- x_{ip} =nonnegative flow of class i on path p

$$f_a^i = \sum_{p \in P} x_p^i \delta_{ap}, \quad \forall i, \forall a$$

$$f_a = \sum_{i=1}^{k} f_a^i, \quad \forall a \in L$$

Link Cost Functions

- Assume as given, a travel time function and a travel cost function associated with each link *a*.

$$t_a = t_a(f) \quad \forall a \in L$$

$$c_a = c_a(f) \quad \forall a \in L$$

Generalized Cost Functions

- Generalized cost of class *i* associated with each link *a*,

$$u_a^i = w_{1a}^i t_a + w_{2a}^i c_a \quad \forall i, \forall a$$

- Where:

$$t_a = t_a(f) \quad \forall a \in L$$

$$c_a = c_a(f) \quad \forall a \in L$$

w^i_{1a} = weight associated with class *i*'s travel time on link *a*
w^i_{2a} = weight associated with class *i* 's travel cost on link *a*

Additional Comments

- Generalized cost of class *i* associated with traveling on path *p*,

$$v_p^i = \sum_{a \in L} u_a^i(\tilde{f})\delta_{ap}, \quad \forall i, \forall p$$

- Travel demand of class *i* traveler between O/D pair *w*,

$$d_w^i = \sum_{p \in P_w} x_p^i, \quad \forall i, \forall w$$

- Travel disutility associated with class *i* traveler between O/D pair *w*,

$$d_w^i = d_w^i(\lambda), \quad \forall i, \forall w$$

Traffic Network Equilibrium Conditions

$$v_p^i(\tilde{f}^*)\begin{cases} = \lambda_w^{i*} & if \quad x_p^{i*} > 0 \\ \geq \lambda_w^{i*} & if \quad x_p^{i*} = 0 \end{cases}$$

$$d_w^i(\lambda^*)\begin{cases} = \sum_{p \in P_w} x_p^{i*} & if \quad \lambda_w^{i*} > 0 \\ \leq \sum_{p \in P_w} x_p^{i*} & if \quad \lambda_w^{i*} = 0 \end{cases}$$

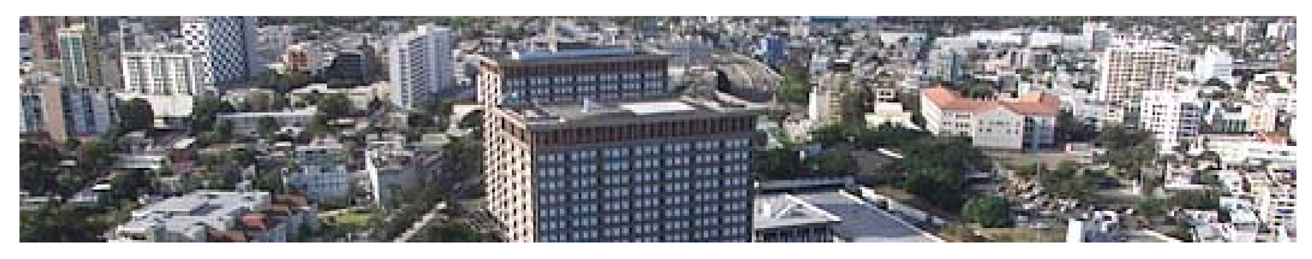
VI Formulation

$$K \equiv \left\{ (\tilde{f}, d, \lambda) \middle| \lambda \geq 0 \quad and \quad \exists \tilde{x} \geq 0 \right\}$$

$$\sum_{i=1}^{k} \sum_{a \in L} u_a^i(\tilde{f}^*) \times (f_a^i - f_a^{i*}) - \sum_{i=1}^{k} \sum_{w \in W} \lambda_w^{i*} \times (d_w^i - d_w^{i*}) + \sum_{i=1}^{k} \sum_{w \in W} (d_w^{i*} - d_w^i(\lambda^*)) \times (\lambda_w^i - \lambda_w^{i*}) \geq 0, \quad \forall (\tilde{f}, d, \lambda) \in K$$

Applying the Model
San Juan Metropolitan Area
Case Study

San Juan Metropolitan Area

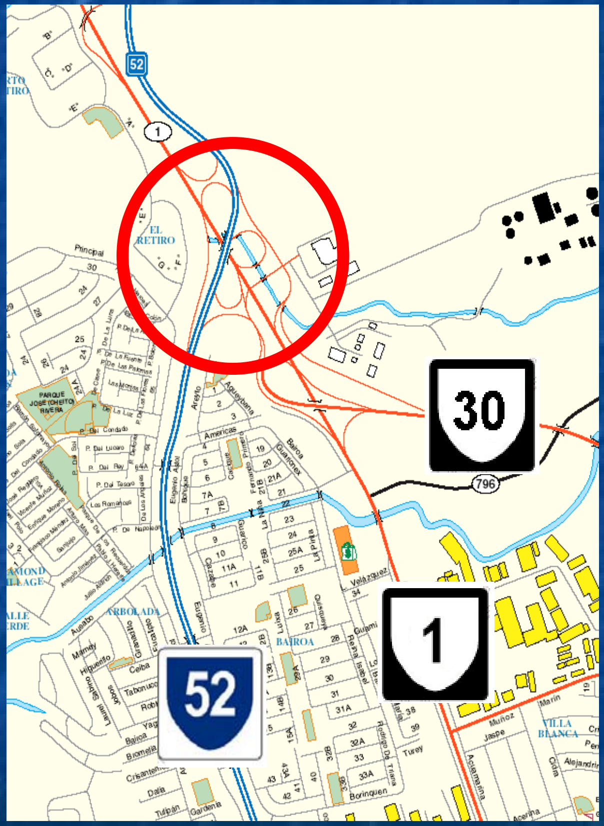


- Area = 400 mi^2
- 1.4 million residents (35% of the total population), generate 3.2 million trips a day
- 63% of the jobs are in the metro area
- It is expected an increase of 45% in the number of trips by 2010

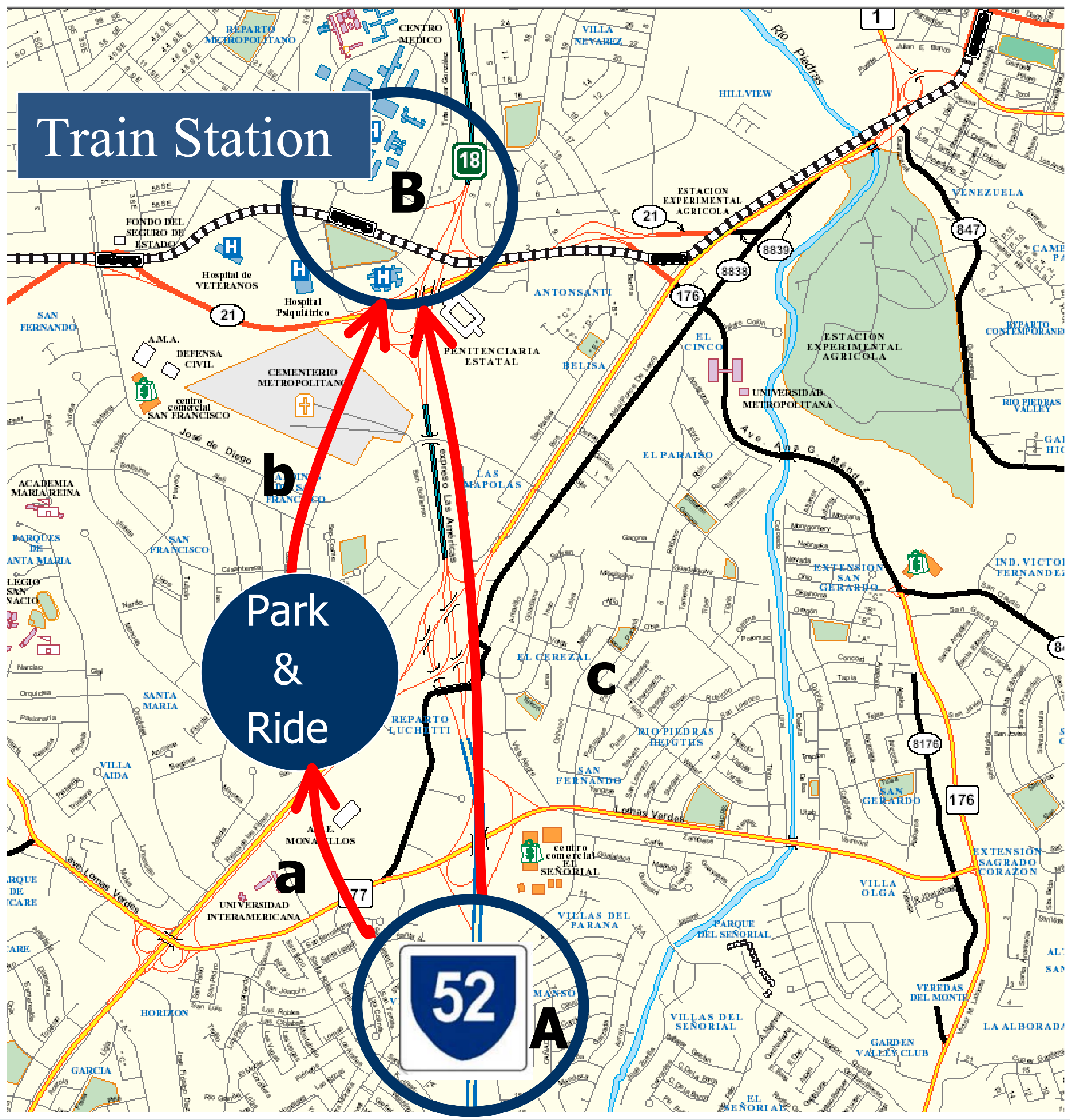
Source: Department of Transportation & Public Works

PR-52 Northbound A.M. Peak Hour

Traffic Network Analyzed



Simplified Network



Link Cost Functions

- Generalized cost functions should reflect the two alternatives available to travelers.
- Alternative 1: using link *c* for private vehicle
- Alternative 2: using links *a* and *b* for transit or HOV

Link Travel Time Functions

$$t_a = t_a(f) \quad \forall a \in L$$

- The travel time for Alternative 1 (private vehicle) should include a congested factor and should reflect driver's comfort when compared with Alternative 2.
- Travel time functions for Alternative 2 (park & ride) should reflect the time required to park, walk and wait and the higher speed that transit and HOV vehicles can reach.

Link Travel Cost Functions

$$c_a = c_a(f) \quad \forall a \in L$$

- The cost functions for Alternative 1 (private vehicle) should include costs such as fuel and tolls
- Travel time functions for Alternative 2 should reflect the cost to park and transit fare

Travelers

- For this example, there are 2 classes
- Travelers in class 1 are highly interested in minimize travel time and relatively low interest in travel cost
- Travelers in class 2 are interested in minimize both travel time and travel cost

Travelers

- Members of a class of travelers perceive their generalized cost on a route as a weighting of travel time and travel cost

This can be represented as weight factors as follows:

w^1_{1a} = weight associated with class *1* travel time on link *a*
w^2_{2a} = weight associated with class *2* travel cost on link *a*

Weights

- We have three links and two classes. We can specify weight for each link:

Class	Travel Time			Travel Cost		
	Weight on Link a	Weight on Link b	Weight on Link c	Weight on Link a	Weight on Link b	Weight on Link c
1	$w^1_{1a} = .75$	$w^1_{1b} = .75$	$w^1_{1c} = .75$	$w^1_{2a} = .25$	$w^1_{2b} = .25$	$w^1_{2c} = .25$
2	$w^2_{1a} = .5$	$w^2_{1b} = .5$	$w^2_{1c} = .5$	$w^2_{2a} = .5$	$w^2_{2b} = .5$	$w^2_{2c} = .5$

Generalized Cost Functions

$$u_a^i = w_{1a}^i t_a + w_{2a}^i c_a \quad \forall i, \forall a$$

Link	Class 1	Class 2
a	u^1_a =0.75 $t_a(f)$ + 0.25 $c_a(f)$	u^2_a =0.5 $t_a(f)$ + 0.5 $c_a(f)$
b	u^1_b = 0.75 $t_b(f)$ + 0.25 $c_b(f)$	u^2_b = 0.5 $t_b(f)$+ 0.5 $c_b(f)$
c	u^1_c =0.75 $t_c(f)$ +0.25 $c_c(f)$	u^2_c =0.5$t_c(f)$ +0.5 $c_c(f)$

Conclusions & Recommendations

- The model allow to evaluate a traffic network considering that travelers use several criteria to choose their optimal travel path
- This can be represented by weights that are class and link-dependent
- The model deal with general and not separable demand functions
- Data needed to construct meaningful travel cost and travel time functions
- Information obtained with this model could provide useful insight into the planning process

References

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- Nagurney, A.; Dong, J. & Mokhtarian, P., Traffic Network equilibrium and the environment: a multicriteria decision-making perspective, 2000
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