

# PUBLIC TRANSPORTATION NETWORKS

## Outline

- Network Structure
- Approaches to Network Design

# Grid And Timed Transfer

## Aims:

- provide reasonable level of transit service for many O-D pairs
- decrease the perception of transfers as major disincentive for riders

## Observations:

- must avoid negative impact on CBD ridership
- what is impact of restricting headways to set figure e.g. 30 min.?
- how much extra running time is required to guarantee connections?
- will transit be competitive in non-CBD markets?
- well-located transfer centers can enhance suburban mobility

# Grid And Timed Transfer

## Conclusions:

- **grid systems work well with high ridership and dispersed travel patterns -- New York City, Toronto, Los Angeles (key here is high frequencies reduce need for timed transfers)**
- **timed transfers work well for urban areas with dispersed focused suburban activity centers, multi-modal networks**

# Pulse

**Aim: to provide convenient one transfer service throughout small urban area**

## **Observations:**

- **route design geared to particular round trip travel time because all routes have same headway**
- **as number of routes increase, harder to maintain reliability, have to increase recovery/rendezvous time**
- **depends on availability of effective pulse point**

## **Conclusions:**

- **well suited for many well focused outer suburban areas and small independent cities**

# Multimodal

**Aim: to provide effective service for both short and long trips**

## **Observations:**

- rail (or other guideway) networks are expensive to build and hence network is limited in length
- rail capacity is high, marginal cost of carrying passengers relatively low
- key issues for new rail lines: to what extent is direct bus service retained as opposed to forcing transfer to rail

## **Conclusions:**

- need to look at total trip time and cost to determine net impact on different O-D trips
- build integrated bus/rail fare policy to encourage riders to take fastest route

# Approaches to Network Design

- 1. Idealized Analysis:**  
broad strategic decisions
- 2. Computer Simulation:**  
detailed analysis tool
- 3. Incremental Improvements:**  
seek opportunities to intervene locally in network
- 4. Global Network Design:**  
synthesize new network
  - fully automated
  - man/machine interaction

# Computer Simulation

## Aim:

- tool to answer what-if questions

## Functions:

- 1) specify system (e.g., route characteristics) and operating environment
- 2) model estimates performance -- transit ridership, costs, etc.
- 3) revise as desire and re-run

# Computer Simulation

## Examples: EMME/2, MADITUC

- network analysis package
  - EMME/2: multimodal, full equilibrium
  - MADITUC: public transportation, fixed transit demand matrix
- strong interactive graphics capabilities for network displays travel flows



# Differentiating Features of Bus Network Models

## 1. Demand

- assumed constant
- assumed variable based on service design

## 2. Objective Function

- minimize generalized cost
- maximize consumer surplus

# Differentiating Features of Bus Network Models

## 3. Constraints

- fleet size
- operator cost
- vehicle capacity

## 4. Passenger Behavior

- system or user optimizing
- single or multiple path assignment

## 5. Solution Technique

- partition into route generation and frequency determination

# Incremental Improvement

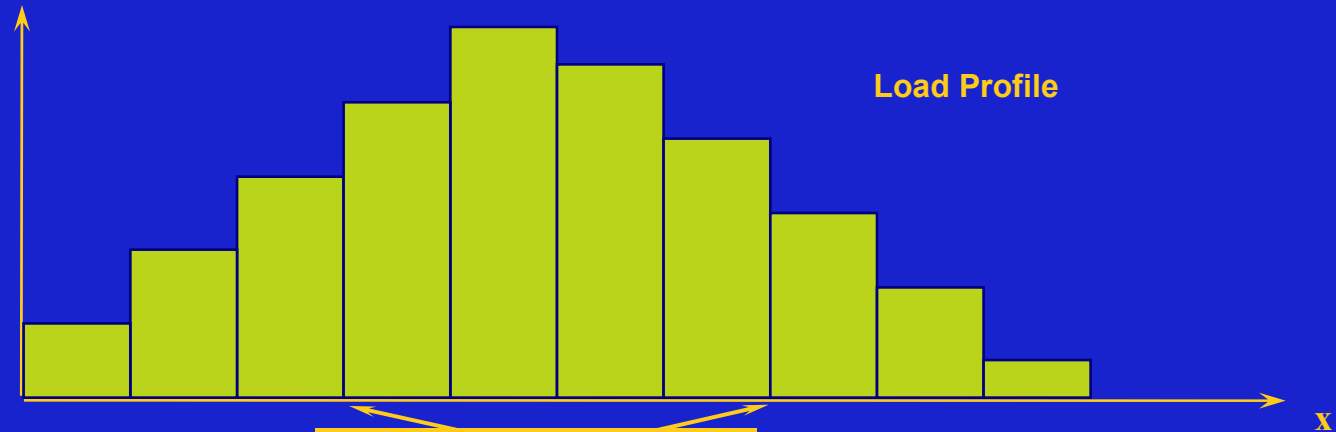
## Aim:

- examine load profiles of individual routes looking for improvement opportunities
- obtain routes characterized by high frequencies and fairly constant loads

## Strategies:

- 1) route decomposition: where frequency is high but load is variable along route
- 2) route aggregation: combine parallel routes to improve frequency or through-route to reduce transfers
- 3) new services: reduce circuitry and operating cost, access new markets

# Route Disaggregation Options

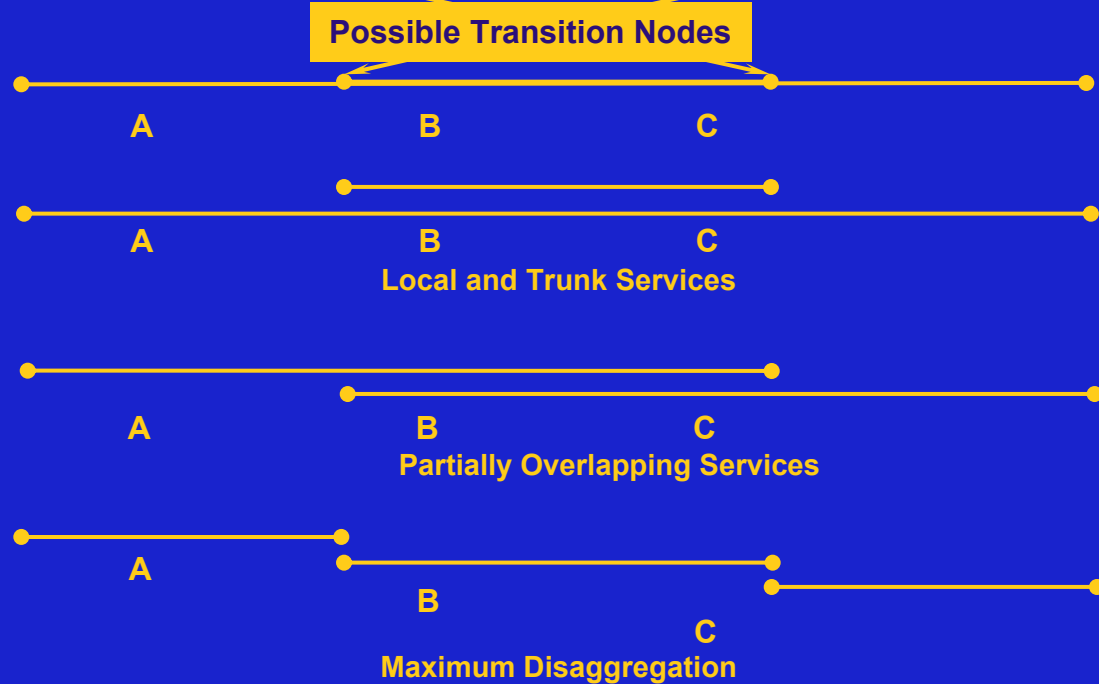


Associated Aggregated O-D Matrix

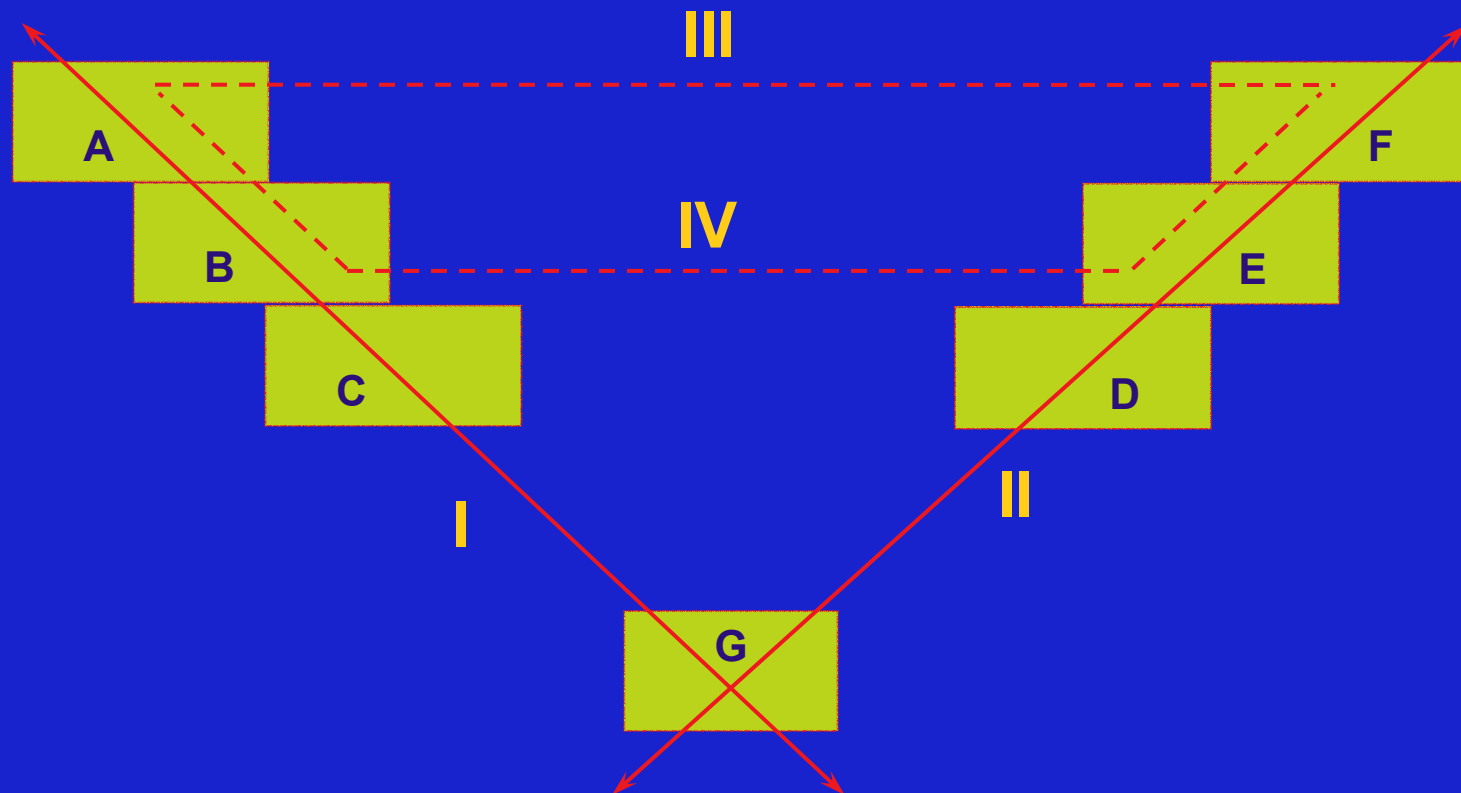
	A	B	C
A	L/M	L/M	L/M
B	L/M	H	L/M
C	L/M	L/M	L/M

A	L-H	M/H	L
B	M/H	H	M/H
C	L	M/H	L-H

A	L/M	L	L
B	L	H	L
C	L	L	L/M



# New Direct Services



# VIPS-II Package\*

## Basic Premises:

- fully automated planning systems won't work
- computer role is to number crunch and organize information
- also solve specific sub-problems
- need interactive graphics for good man-machine communication
- need variable demand

## Main Objective:

Maximize number of passengers subject to constraints on:

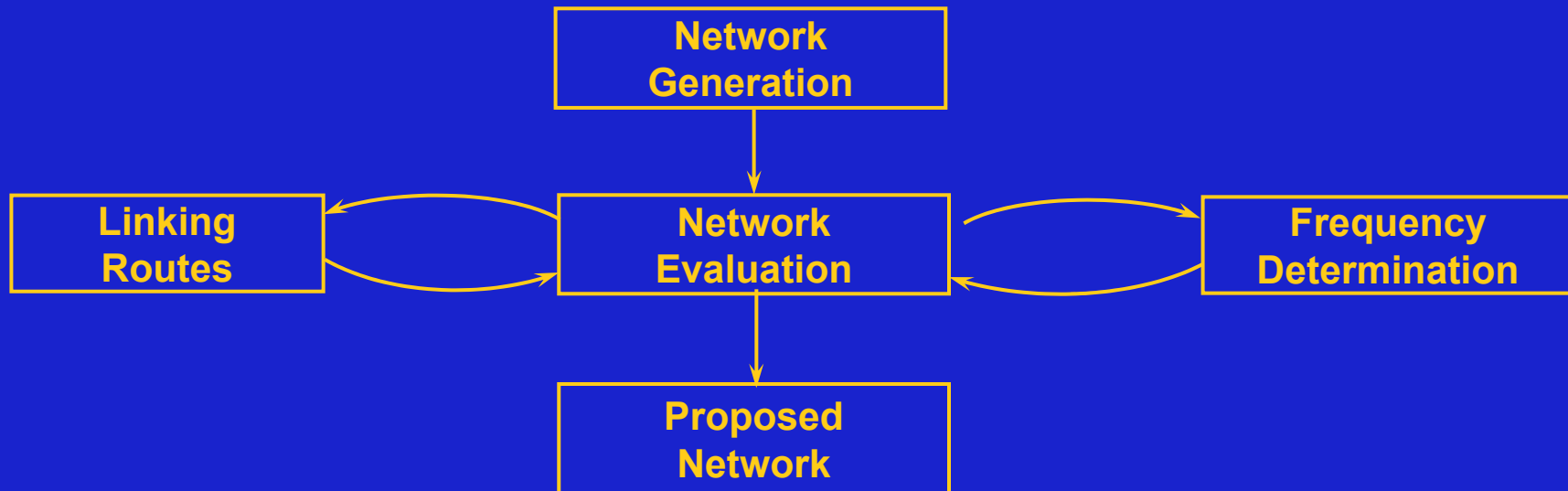
- operator cost
- minimum level of service

*\* from "Public Transportation Planning, a Mathematical Programming Approach" by Dick Hasselström. Göteborg, Sweden, 1981.*

# General Model Structure

## Specific Sub-Problems:

- evaluation of a proposed network
- frequency determination for given routes
- linking routes at junction
- generation of initial route network



# NETWORK DESIGN APPROACHES

- A) Start with fully connected network and eliminate the weakest routes iteratively, reassigning passenger flows to the best remaining routes**
- B) (i) Start with the following route design principles:**
- most high demand O-D pairs should be served directly
  - only certain modes are suitable for route termini
  - routes should be direct and not be circuitous
  - routes should meet to facilitate transfers
- (ii) Generate a large number of possible routes heuristically**
- (iii) Select final set of routes through optimization problem formulation.**