Cluster 2/Module 2 (C2/M2): Introduction to Network Design.

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This presentation addresses the importance of network planning and design in meeting diverse travel needs. It covers the following topics:

- Definition of public transport network
- Four key network planning principles
- Common network orientation designs
- Product (route/service) differentiation related to markets served and functions provided
The term *network* often is used in every day conversation. People complain that their company’s computer network is down and they cannot communicate with their co-workers. Newspaper reporters write stories about the features and costs of different wireless telephone networks. People out-of-work are encouraged to “network” with their friends and business associates to learn about potential jobs.

The term *network* also is used in conversations about transportation. We talk about highway networks, railroad networks, airline networks, and, of course, public transport networks.

But have you ever stopped to think about what is meant by the term *network*. Particularly, what is a public transport network?

Commonly, people define a public transport network as the sum of all public transport services in a city or region.

However, when the effectiveness of a public transport network is being evaluated, a more technical definition is used that assumes that the individual services are designed to form a system. The services in this system are connected in space and time. The services intersect at common locations. The arrival and departure times of the intersecting services are coordinated. This allows passengers make journeys on the network that require the riding of more than one route.

Many public transport networks “grow” in response to increases in the size of the respective cities without any particular strategy in mind. Routes are added and existing ones extended. It is, however, desirable for the network to be based on a strategy for achieving specific goals. Examples are:

- Offer reliable, fast service to center city
- Provide a high level of service connecting all trip origins and destinations
This more technical goal has two implications. First, the effectiveness of a network is not just measured against the achievement of goals for the system as a whole. The effectiveness of network also is measured on a route by route basis. A well-designed network is one in which all individual routes perform well, there are “no weak links.” Also, a well-designed network must provide connections between routes so passenger can travel to all destinations served with minimum inconvenience.

The second implication is that effectiveness depends on good network design. This means not only designing good individual routes, but also the connections among the routes. Network planners must always keep both points-of-view in mind as they plan services.

Now let us move from our theoretical discussion of public transport networks to practical challenges.
What are the real world challenges facing network planners? There are two challenges that relate to the complexity of urban travel.

The first challenge is that the public transport network must serve multiple and different travel markets. These markets have different origin-destination patterns and different trip purposes. The demand for travel occurs at different times of the day and on different days of the week.

The second challenge is serving markets that can only be served by requiring passenger to ride more than one service. Ideally, services should be offered that allow all riders to travel from their origins to their destinations on one route. Unfortunately, it is not financially feasible to serve all markets or passenger trips with a one-seat ride. Some trips can only be served efficiently by requiring riders to ride more than one route.

These challenges are difficult. However, the following four messages provide good guidance on how to approach these challenges in network planning.

- Must serve multiple and different travel markets
  - Different origins and destinations
  - Different trip purposes
  - Different times of travel by hour, day of week
- One-seat ride from origin to destination is ideal, but not always possible
  - Some trips require multiple services and even modes
- The next four key messages guide good network planning

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The first message is to design the network to serve specific travel markets. The network design should not be based on theory or what is popular at the moment. It should be based on a thorough analysis of current travel in your city.

There are a variety of trips that are made in a city every day. These trips should be viewed as separate travel markets that are defined by origin and destination patterns, trip purpose, and time of travel.

Different travel patterns require different transport services. Some origin and destination patterns are concentrated on one key destination. Examples are workers commuting to jobs in the center city or students traveling to school. These services can be served with high-capacity vehicles that operate very frequent routes.

Other origin and destination patterns are dispersed among many destinations. These patterns are common for suburban travel to work locations and shopping areas. These services can be served with small vehicles that operate on low-frequency routes.

The purpose of the travel and when the trips are taken also are important. Commuting travel to work often is concentrated in a few hours of the day and typically on weekdays. This generally requires the operation of very frequent service using high-capacity vehicles.

In contrast, non-work travel is more distributed across the day and the week. Examples of non-work travel are shopping trips, medical trips, recreational trips, and trips to visit friends. Non-work trips may be served with large or small vehicles depending on the specific origins and destinations of the
The second message is that one-seat rides are ideal, but transfers are permissible if they are well-executed. Research shows that travelers view transferring as a “hassle” because of several factors:

- Physical effort spent walking and climbing stairs between transport connections
- Mental effort in finding the right path between the connections
- Time spent waiting for the connecting vehicle
- Time spent making a second fare payment

However, transfers do work when the impacts of these factors are minimized. This can make public transport competitive with other travel alternatives.

How do you reduce the hassle of transferring? Provide short walking distances and eliminate the need to climb stairs. Offer easy ways of finding information. Coordinate schedules so that waiting times are minimal. Finally, eliminate the need to make a second fare payment.
The third message is philosophical — recognize that planning is a dynamic and iterative process. Planning does not stop after a transport system is built. Planning must be ongoing.

The obvious reason is that travel markets are continually changing because of population and employment growth. New developments occur and trip patterns change. The system designed 10 years ago may not serve all of these new travel demands. The state of the economy will either accelerate or slow these changes.

Less obvious is the learning that happens when a plan is implemented and a transport system is built. When it becomes operational, we become aware of constraints or problems that were not obvious during the initial planning stage. We need to have an ongoing process to address these problems and new opportunities.
The final message is that simplicity and understandability are virtues. We want a service network that can be easily communicated and understood. If we are not careful, we may design a system that is technically efficient, but not used because few people know how to ride it.

Why is this a challenge? Because a traveler needs several pieces of information to plan a trip including:

- Types and number of potential services
- Schedules
- Stop and interchange locations
- Fare payment

As we design services, we should always be mindful of these trip maker needs and not make our services unnecessarily complicated. We should use simple ways to communicate how to use the public transport system.
the next few slides are going to look at two types of network design themes.

First, we are going to look at network orientation. Orientation refers to the physical location of the public transport services. The two general types are radial and grid.

Then, we are going to look at the different types of services operated. Another way to say this is the different kinds of products offered. These routes serve different markets, but also serve different functions within the service. We will discuss what we mean by functions.

Let us now discuss in more detail these network design themes.
A radial network is the traditional public transport network. The idea behind this network is that most people are traveling to the city center. Why? Because all activity occurs in the center city — jobs, shopping, entertainment, and government.

Does all activity occur in your city center? In the past, this may have been true, particularly if walking was the only travel option. However, as cities grew, the importance of outlying parts of a city also grew and more travel options became available.

How well does a radial network serve travel between outlying areas? It serves well direct travel through the center city (e.g., from the southwest corner to the northeast corner on routes C and G). However, it is poor in serving travel between adjoining areas (e.g., travel between the southwest corner (C) and the west side (D) must go all the way to center city and back out).
The metro systems in many cities are designed as radial networks. For example, metro lines operated in Chicago all converge on the central city. The Chicago downtown area is known as “The Loop” because the old metro lines circled the downtown on elevated structures.
The grid is the other major type of network. This network recognizes that, in some cities, there is not a dominant center city, but instead a number of dispersed activity centers.

Services are operated primarily north-south and east-west. Travelers can reach any destination by making only one transfer. This requires that high-frequency service be operated on all services to minimize transfer waiting time.

What is the major disadvantage of this network? More people must transfer. It takes a good communication program to show people that these transfer trips can be made easily.
Bus systems in large cities often employ grid networks. The bus network in Chicago is a grid system. It provides convenient access to most destinations in Chicago.

In addition, the bus system is integrated with the metro system. More than 50% of Chicago’s metro users ride a bus to reach their metro station.
The second network theme might be called route differentiation. Marketers have found that it is hard to design one product to fit everyone’s needs. Products must be tailored to fit individual market segments. Think about how many types of mobile phones are offered today.

The public transport markets vary in several ways such as trip purpose, trip length, and quality of service. These attributes can be combined to identify specific market segments such as long-distance work trips to the city center or short-trip services in downtown areas. They often are served by different functional route types such as trunk, feeder, and local services.

The route differentiation approach is being adopted in many cities. Let us look at typical types of services and how they are marketed or branded.
One common type of differentiated route is a neighborhood circulator. A circulator provides service for short-distance travel within a neighborhood or community. It also provides connecting service to other transport routes.

The circulators operate all day on fixed-routes, although sometimes “on-call” deviations are made. For example, a bus may go off-route to person’s home if the home is with 1 km of the route. Typically, the circulators operate on secondary and residential streets.

The stops are simple and frequent. Sometimes buses will stop anywhere they are “hailed” by a passenger.

The vehicles are small and easy to board. Fare collection is often done on-board.
The picture shows the neighborhood circulator operating in Coimbra, Portugal. It is known as “Linha Azul” or Blue Line.

The Blue Line identity is built into the livery of the bus — a blue line circles the bus below the window. People can quickly identify this bus without looking at the signs on the back or front windows. (In this image, we see the back window.)

Also notice that a blue line is painted on the street pavement. The painted line clearly shows the routing of the bus to residents and visitors to the area. On a more subconscious level, it indicates that the route is a permanent part of the community.

Finally, notice the size of the bus. It is small and seems to fit the character of the neighborhood.
A larger-scale circulator bus is operated in Washington, DC. Five routes link cultural, entertainment, and business destinations within the city's central core.

The buses have their own unique livery or bus exterior design. The destinations served are shown on the side of the bus. People can quickly identify this bus without looking at the signs on the back or front of the bus.

The buses are enormously popular. Surveys have found that the unique branding and simplicity of routes have attracted many tourist riders.
The next type of differentiated route is local bus service. A local provides basic mobility for all trip purposes and serves trips that go outside the immediate community. It also provides connecting service to other transport routes.

The locals operate all day on fixed routes. Typically, the locals operate on the major arterial streets in the city. The trips have many origins and destinations.

The stop spacing is wider than for circulators, but can be as low as every 200 meters. The stops are simple, but some shelters are provided at busy stops.

The vehicles are common large urban buses that are at least 12 meters long. Interior space is configured for both seating and standing since crowding is expected. Fare collection is often done on-board.
These pictures show the local buses operated in York, Ontario, Canada. Notice that the buses have two doors. Passengers pay as they enter the front door. Passengers may exit through either the front or back doors.

Finally, notice the size of the bus — about 12 meters. This size of vehicle fits the urban environment, but would look out of place as a circulator bus in the smaller neighborhoods, such as the earlier example in Portugal.
Commuter express service is designed to provide high-speed and high-comfort service. This type of service typically serves long-distance commuter work trips to large activity centers. These trips have large numbers of travelers commuting from a few origins to one or sometimes two destinations. The journey times are long and often exceed one hour in each direction.

The service is concentrated during commuting hours on work days with limited or no service offered in midday. Commuter express operates either on high-speed roads or on rail lines. Stop spacing is wide and often limited, sometimes with no stops between outlying areas and the center city.

The vehicles provide comfortable, cushioned seating. Limited standing capacity is provided, but every passenger expects to get a seat.

Fare collection varies and can be on or off board.
The public transport system in Toronto, Canada, GO Transit, offers commuter express service on both buses and commuter rail cars. The buses are high-quality inter-city buses that have high-back seats and foot-rests and are air-conditioned. Both single and double deck buses are used.

The commuter cars also are high-quality and have high-backed seats and air-conditioning.

GO Transit is somewhat unique in that it has integrated rail-bus schedules. On some routes, both bus and rail services are offered depending on the time of day.
Rapid transit serves high-volume corridors that have many origins and destinations. Rail service is commonly called metro while bus rapid transit is known by the acronym BRT.

Rapid transit serves all travel trip purposes. Trip lengths are medium to long. This produces significant passenger turnover — constant on-off activity at many stations.

The daily service often spans more than 18 hours (e.g., 6 AM to 12 midnight). High-frequency service is provided with intervals between 3 and 10 minutes.

Stop spacing ranges between 1-2 KM. Many stations serve as development nodes for commercial and residential activity.

The vehicles have large passenger capacities. The mixture of seating and standing areas vary by city, but commonly large areas are devoted to standing.

There are multiple, wide doors to provide fast passenger entry and exiting. Also, to speed entry and exiting, fare collection is done off-board.
Examples of bus and rail rapid transit are found in Toronto, Canada. The Toronto Transit Commission operates four rapid transit lines — three subway lines and one at-grade line. Four- and six-car trains are operated. Service intervals range from two to six minutes depending on the time of day.

York Region Transit operates five BRT routes in suburban Toronto. The buses are 12 and 18 meters long. Service intervals range from 5 to 10 minutes depending on the time of day.
Route differentiation can facilitate providing information to the public. Seoul, Korea is a good example of how this concept has been applied.

The buses in Seoul have been classified in a functional hierarchy of four levels. Each function has buses that are painted a specific color as follows:

- The blue bus is a trunk line that provides service between the suburbs and the downtown. It functions as a local service since the bus makes frequent stops.
- The green bus is a feeder line that provides neighborhood/community circulator service and connects to the trunk lines and subway lines.
- The yellow bus is a circular line for providing local bus service within the downtown area.
- The red bus is an express trunk line to link metropolitan area and the downtown area.
These are pictures of the four functional bus types. Because of their colour, people can quickly identify each type of bus service without looking at the signs on the sides or in front window.
In this module, we provided an overview of network design principles. This overview can be summarized into three points.

First, a good public transport system should be designed to serve specific travel markets. There are a variety of trips that are made in a city every day. These trips should be viewed as separate travel markets that are defined by origin and destination patterns, trip purpose, and time of travel.

Second, networks with different route types best serve multiple travel markets. Marketers have found that it is hard to design one product to fit everyone’s needs. Products must be tailored to fit individual market segments.

Third, integration is key to success. While we should design market-specific routes, we should ensure that the services are integrated. This means we should make special efforts to integrate schedules, fares, physical facilities, and passenger information.