3. Urban Transportation Planning Process
Definitions:

- **Planning**: The process of working out, beforehand, scheme, program, or method for the accomplishment of an objective.

- **Urban Transportation Planning**
  1. Understand how decisions to build transportation facilities are made
  2. Understand basic elements of the transportation planning process.
  3. Understand basic elements of travel forecasting
Urban Transportation Planning

First Phase
- Survey, data collection and Inventory

Next Phase
- Analysis of data collected and building models.

Points in Urban transportation Planning
1. Forecast of Urban population and economic growth for the targeted year of the metropolitan area.
2. Allocation of land use and socio-economic projection to individual analysis zones according to land availability, local zoning and related public policies.
3. Generation of alternative transportation plan based on the result of 1 and 2.
4. Calculation of the capital and maintenance cost of each alternative plan.
5. Application of the calibrated demand forecasting models to predict the targeted year equilibrium flows expected to use each alternative, provided land use and socio economic projection and characteristics of alternatives.
6. Conversion of equilibrium flows to direct user benefits, such as saving in travel time and travel cost attributable to the proposed plan.
7. Comparative evaluation and selection of the best alternatives based on estimated cost and benefits.
## Basic Elements of Transportation Planning

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Situation definition</td>
<td>Inventory transportation facilities, Measure travel patterns, Review prior studies.</td>
</tr>
<tr>
<td>Problem definition</td>
<td>Define objectives (e.g., Reduce travel time), Establish criteria (e.g., Average delay time), Define constraints, Establish design standards</td>
</tr>
<tr>
<td>Search for solutions</td>
<td>Consider options (e.g., locations and types, structure needs, environmental considerations)</td>
</tr>
<tr>
<td>Analysis of performance</td>
<td>For each option, determine cost, traffic flow, impacts</td>
</tr>
<tr>
<td>Evaluation of alternatives</td>
<td>Determine values for the criteria set for evaluation (e.g., benefits vs. cost, cost-effectiveness, etc)</td>
</tr>
<tr>
<td>Choice of project</td>
<td>Consider factors involved (e.g., goal attainability, political judgment, environmental impact, etc.)</td>
</tr>
<tr>
<td>Specification and construction</td>
<td>Once an alternative is chosen, design necessary elements of the facility and create construction plans</td>
</tr>
</tbody>
</table>
Example 1: Planning the relocation of a rural road (simple, yet good enough to explain the steps)

Step 1: Situation definition:

to understand the situation that gave rise to the perceived need for a transportation improvement
Step 2: Problem definition

Purpose of the step: Describe the problem in terms of the objectives to be accomplished and translate those objectives into criteria.

- Example:
  - Objective = Statements of purpose: Reduce traffic congestion, Improve safety, Maximize net highway-user benefits, etc.
  - Criteria = Measures of effectiveness: Travel time, accident rate, delays (interested in reductions in these MOEs).
Step 3: Search for solutions

- Alternative Routes for Highway Relocation

- Currently constructed bridge
- Alt. 4 (new road)
- US 1
- Alt. 3 or 4 (new road)
- High-accident section
- Alt. 2 reconstruct old road
- New bridge
- Town
- Alt. 1 (new road)
- Harrington River
- US 1A
Step 4: Analysis of performance

Estimate how each of the proposed alternatives would perform under present and future conditions.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed (mph)</td>
<td>25</td>
<td>55</td>
<td>30</td>
<td>30</td>
<td>55</td>
</tr>
<tr>
<td>Distance (mi)</td>
<td>3.7</td>
<td>3.2</td>
<td>3.8</td>
<td>3.8</td>
<td>3.7</td>
</tr>
<tr>
<td>Travel time (min)</td>
<td>8.9</td>
<td>3.5</td>
<td>7.6</td>
<td>7.6</td>
<td>4.0</td>
</tr>
<tr>
<td>Accident factor</td>
<td>4</td>
<td>1.2</td>
<td>3.5</td>
<td>2.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Construction cost ($ million)</td>
<td>0</td>
<td>1.50</td>
<td>1.58</td>
<td>1.13</td>
<td>1.54</td>
</tr>
<tr>
<td>Residences displaced</td>
<td>0</td>
<td>7</td>
<td></td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>City traffic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>2620</td>
<td>1400</td>
<td>2620</td>
<td>2520</td>
<td>1250</td>
</tr>
<tr>
<td>Future (20 years)</td>
<td>4350</td>
<td>2325</td>
<td>4350</td>
<td>4180</td>
<td>2075</td>
</tr>
<tr>
<td>Air quality (µg/m³ CO)</td>
<td>825</td>
<td>306</td>
<td>825</td>
<td>535</td>
<td>386</td>
</tr>
<tr>
<td>Noise (dBA)</td>
<td>73</td>
<td>70</td>
<td>73</td>
<td>73</td>
<td>70</td>
</tr>
<tr>
<td>Tax loss</td>
<td>None</td>
<td>Slight</td>
<td>High</td>
<td>Moderate</td>
<td>Slight*</td>
</tr>
<tr>
<td>Trees removed (acres)</td>
<td>None</td>
<td>Slight</td>
<td>Slight</td>
<td>25</td>
<td>28</td>
</tr>
<tr>
<td>Runoff</td>
<td>None</td>
<td>Some</td>
<td>Some</td>
<td>Much</td>
<td>Much</td>
</tr>
</tbody>
</table>

* Relative to statewide average for this type of facility.
Step 4: Ranking of alternatives (in terms of MOE)

<table>
<thead>
<tr>
<th>Criterion/Alternative</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel time</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Accident factor&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Cost ($ millions)</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Residences displaced</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Air quality</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Noise</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Tax loss</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Trees removed (acres)</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Increased runoff</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Note: 1 = highest; 5 = lowest.

<sup>a</sup> Relative to statewide average for this type of facility.
Step 5: Evaluation of alternatives

Determine how well each alternative will achieve the objectives of the project as defined by Criteria.
Step 6: Choice of project

Based on the alternative evaluation in Step 5, we will choose the best alternative for design and eventual construction. The best choice may not be built because of opposition by the people of the community that is affected.

Step 7: Specification and construction

Once the project has been chosen, a detailed design phase is begun, in which each of the components of the facility is specified.
Travel demand forecasting

- Travel demand forecasting is estimating the demand for transport facilities and services for future design period.
- Important component for transportation planning
  - Trips produced and attraction (How many trips)
  - Decision on destination (where to go)
  - Modal decision (Which mode to use)
  - Spatial decision (Which route to use)
Convectional method of transportation forecasting
3.1. Planning Phase: Trip generation, trip distribution, modal split and Traffic assignment
Trip Generation and Attraction

- Estimates the number of trips from given origins and destinations.
Trip Classification

a) Trips classification based on Purpose:
   I. Home based (HB) trips [80-85% of total trips]
      I. Trips to work
      II. Trips to school or collage
      III. Shopping trips
      IV. Social and recreational trips
      V. Other trips
   II. Non Home based trips [15-20% of total trips]

b) Trip classification based on the time of the day
   I. Peak period (8:30am - 10:30am and 4pm-6pm)
   II. Off Peak period

c) Trip classification based on person type
   I. Trip based on income level
   II. Trip based on vehicle ownership
   III. Trip based on Household size and structure.(single, married, Joint family etc)
Factors affecting personal trip production

- Income and standard of living
- Vehicle ownership
- Household structure and size
- Number of employment and non-employment member in HH
- Value of land
- Population of Residential density
- Accessibility (Distance from central business district)

Factors affecting personal trip attraction

- Characteristics of the land use
- Retail floor area, service and office floor area and manufacturing and wholesaling floor area.
- Employment opportunities.
- Distance from city center or location of service.
- Accessibility (Extend and Quality of transport service to the zone)
Trip generation model and their analysis

- Trip generation model can be derived at two level of aggregation
  1. Aggregate or Zonal based
  2. Disaggregate or Household based (HH) based.

Operational approaches to trip generation modeling are
  1. Growth factor model
  2. Linear Regression model
  3. Cross classification (category analysis) models
A. Growth factor modeling

- Predicts the number of trips produced or attracted by a household or zone.
- Linear function of explanatory variables.
- Basic equation: \( T_i = F_i * t_i \)

\( T_i \) and \( t_i \) are future and current trips in zone \( i \) respectively.

\( F_i \) is the Growth factor, which depends on explanatory variables as:

- Population (\( P \))
- Average Household income (\( I \))
- Average vehicle ownership (\( V \))

\[ F_i = \frac{f(P_i^d I_i^d V_i^d)}{f(P_i^c I_i^c V_i^d)} \]

\( d \) and \( c \) represent design and current year respectively.
B. Linear Regression method

- A linear regression model is developed between dependent variable \( Y \) and independent variable \( X \) in the form of \( Y = a + bX \)

  \( a \) and \( b \) are constant where \( a = \bar{Y} - b\bar{X} \) & \( b = \frac{\sum xy}{\sum x^2} \)

- Two types commonly used

  1. Uses aggregated data at zonal level with average number of trips per household in the zone as the dependent variable and average zonal characteristics as the independent (explanatory) variable.

  2. Uses disaggregated data at the household or individual level with the number of trips made by a household or individual as the dependent variable and the household and personal characteristics as the independent variable.

Coefficient of determination \((R^2 \text{ value})\)

The ratio of sum of squares explained by the regression to the total sum of squares

\[
R^2 = \frac{\sum y_\varepsilon^2}{\sum y^2} \quad \sum y^2 = \sum y_d^2 + \sum y_\varepsilon^2
\]
C. Category analysis or cross classification analysis

- Developed by Wotton
- Picks for the determination of trips generated.
- It overcomes the disadvantages of Regression analysis of assuming the linear relationship between dependent and independent variables.
- It is technique for estimating the trip production characteristics of Households, which have been sorted into a number of separate categories according to a set of properties that characterize the household (household size, income level, vehicle ownership etc.)
Trip Distribution

- Determines the destination for each trip from a given origin
- It is defined as the interchange between zones and deals with the spatial interaction between them. Thus trip distribution models connects the trip origins and destination estimated by the trip generation models to create estimated trips.

Method of Trip distribution

A. Growth factor Models
   - Uniform growth factor \( UGF = \frac{\text{Total future trips}}{\text{Total present trips}} \)
   - Average factor method
   - Detroit method
   - Frater Method
   - Furness Method

B. Synthetic Models
   - Gravity/Spatial Interaction Models
   - Opportunity Model
   - Regression/Econometric Models
   - Optimization Model
   - Tanner model
Growth Factor Trip Distribution Model

**Advantages**

- Advantageous for short term forecasting at urban area where growth factor is more or less constant.
- Used to estimate trip interchanges involving traffic outside traffic area where other models are difficult to adopt.
- It can be used as a check for the values obtained from other model.
- Used when forecast is to be done in quick time.

**Limitation**

- It just multiply the present trips by growth rate, it may be inaccurate for new city and also for city development to saturation.
- If present traffic is 0 the future traffic will also be 0, may not be valid.
- If there is error in present day traffic so will be calculated in future day traffic.
- Tedious method as large number of iteration need to be done.
- It doesn't provide a measure of the resistance to travel.
- Not suitable for policy studies like introduction of a mode, impact on trip distribution pattern by restricting autos in certain zones.
- They neglect the effect of changes in travel pattern by the construction of new facilities and new network.
- In case of Uniform Growth factor method the future trips of each zone may not tally with the predicted value.
Gravity Model

- Mostly used synthetic model of trip distribution.
- Newton’s gravity model and gravity model have similar principle.
- Its principle is number of trips between two zones is directly related to activities (trip production at origin and attraction at destination) in the two zones and inversely related to the separation between the zones as a function of travel time as:

\[ T_{ij} = K \frac{P_i A_j}{d^n} \]

- \( T_{ij} \) represents number of trips from I and j
- \( P_i \) and \( A_j \) production of zone i and attraction of zone j
- \( K \) and \( n \) represent constant, which value need to be calibrated
- \( d \) be the distance between I and j

\[ T_{ij} = \frac{P_i A_j F(t_{ij}) K_{ij}}{\sum_{j=1}^{n} A_j F(t_{ij}) K_{ij}} \]

- \( F(t_{ij}) \) = friction factor (\( F = A/W_c \)), where \( C \)=calibration factor, \( W \)=Impedance
- \( K_{ij} \) = a socioeconomic adjustment factor
- \( n \) = number of zones
Mode Choice / Modal split models

- Determines the mode choice for each trip.
- The distribution of trips over the various transport modes (car, bike, public vehicle etc) is called modal split.
- Modeling transport mode choice is one of the classical problems in traffic engineering.
- It predicts the no. of trips using the particular mode say private or public vehicle.

**Types of modal split modals**

1. Trip end modal split modals
   - Used after trip generation considering only personal characteristics.
   - Basic assumption of the trip end type models is that transport patronage is relatively insensitive to the service characteristics to the transport modes and is determined principally by the socioeconomic characteristics of the trip makers (Income, residential density and car ownership)

2. Trip interchange modal split modals
   - Modal split modal that followed the trip distribution phase
   - Its advantage is that it is possible to include the characteristics of the journey and that of the alternative modes available to undertake them.
Factors affecting Mode choice

- **Trip Maker Characteristics**
  - Income
  - Vehicle ownership and availability of vehicle in HH
  - Family size and composition (couple with children, retired people)
  - Possession of driving license
  - Habit of trip maker and standard of living
  - Residential / Population density

- **Modes or Transportation system characteristics**
  - Relative travel time of each mode (in vehicle time, waiting time, walking time)
  - Monetary cost of each modes
  - Comfort and convenience of each mode
  - Reliability and regularity of each mode
  - Parking availability and cost
  - Protection and security level of each modes

- **Environmental characteristics**
  - Climatic condition
  - Road condition and Visibility
Utility and disutility function

- Utility functions measures the degree of satisfaction that people derive from their choices.
- A disutility function represents the generalized cost of travel associated with all the possible model.
- Both are linear weighted sum of various independent variables (mostly travel time and cost).
- A utility based modal choice modal estimates the market share of each mode based on utility or disutility associated with it.
- Types
  - Deterministic modal: if the traveller can select the modes with highest utility.
  - Probabilistic modal: if the modes are selected in proportion based on the modal utilities (all the modes have certain share).
Multinomial Logit (MNL) Model

- The Logit formulation is a share model that divides the group of travelers between the various modes depending on utilities associated with each mode.
- The probability of choosing alternative mode “i” out of a total of “n” available modes is as per multinomial Logit model or Simply Logit model is

\[ P_i = \frac{e^{\mu U(i)}}{\sum_{i=1}^{n} e^{\mu U(i)}} \]

\( \mu \) = dispersion parameter, whose value need to be determined through detailed investigation and for simplicity \( \mu=1 \) is assumed. Thus the logit model becomes

\[ P_i = \frac{e^{U(i)}}{\sum_{i=1}^{n} e^{U(i)}} \]

\( P_i \) = Probability of choosing alternative “i”

\( U \) = Observable utility of travel mode “i“

If instead of utility, disutility function is provided we need to convert it to utility function

\( U_i = -\beta \times C_{ij} \)  
For numerical purpose we can consider \( \beta=1 \)
**Captive**

- People who have no choice but to use one or other transport mode are called captive of that transport mode.

**Choice Traveller**

- Those people who are not captive to one other form of transport are called choice traveller.

**Public Transport Captive**

- When a house hold has no access to a car while the destination is too far away to cycle or walk and when family income does not stretch to hire car or taxi, the family member is said to be public transport captive.
Traffic Assignment

- Trip or traffic assignment is the last phase of the four-step transportation planning process which concerned with trip maker's choice of path between pairs of zones by travel mode and with the resulting vehicular flows on the multimodal transportation networks.
- Determines the specific route for each trip
- Three preliminary questions must be dealt with prior to the performance of network assignment:
  1. The first is related to the difference between intra-zonal person- trips and intrazonal vehicle trips.
  2. The second is related to the difference between daily trips (i.e. the estimate of the 24-hr demand versus the diurnal (time of the day) distribution of this demand.
  3. The third is concerned with the direction of travel of the trip to be assigned on the transportation network.
1. Person - Trip and vehicle Trip

- The forecast of the person - trip and vehicle - trip flows that are expected to use the transportation system are both relevant to the assessment of its performance.

- The estimate of person-trips that desire to use a highway, for example, provides an indication of the passenger throughput that will be accommodate.

- On the other hand, the LOS that the trip makers experience when traveling on a highway is related to the vehicular flow (e.g., veh/hr) that desires to use the highway.

- For this reason the estimated inter-zonal person-trips must be translated into vehicular trip to performing the highway trip assignment.

- Mass transit (or transit assignment) must address another issue as well, it consists of fixed facilities that constitute the modal network and the scheduling of the transit service.

- This means that analysis of a particular transit alternative must address the question of whether a proposed fleet size and operating schedule and the relating flow provide sufficient capacity to meet the anticipated inter-zonal person-trip demand.
2. Diurnal (Time of day)

- The road network flows that are used to calculate the prevailing level of service are expressed in veh/hr or pcu/hr.

- On the other hand, the estimates of inter-zonal flows that are obtained by the trip generation distribution, mode choice sequence are often based on 24 hr period.

- But the demand for transportation exhibits a highly peaked pattern with sharp peak period in the morning and generally longer but less pronounced peak period in the evening. It is appropriate to investigate the performance of the transportation system under peak demand conditions when capacity limitation become critical.

- The time variation of demand is most relevant to mass transit planning because scheduling of service is typically tailored to the variation of demand over 24 hr period.

- The diurnal distribution of demand may be estimated through the use of factors taken from observation during base year.
3. Trip Direction

- It is desirable that the assignment of trips (especially by the time of day) retains the direction of these trips. The predominant direction of travel during the morning peak period is toward major activity centers (i.e. CBD, schools, etc.) and the reverse is true during the evening peak period.
Route Choice Behavior

The key to assigning users on the network is the underlying behavior assumption of route choice, in 1952 Wardrop established two principles of route choices:

1) According to the first principle, users choose the route that minimize their own travel time. (shortest path) (user equilibrium).

2) Users distribute themselves on the network in such way that the average travel time for all users is equal. (system equilibrium, total cost of using the system is minimized), (fuel consumption)

3) Stochastic equilibrium: each user assign himself /herself on path that he or she think is the shortest.
Route Assignment Technique

1) **All -or -nothing assignment or Minimum path technique**
   - This is simple, inexpensive and fast method, with absence of capacity and congestion effects.

**Assumptions**

- Link cost are fixed i.e. no congestion
- All travellers think in similar way i.e. each driver choose the same route for same set of O-D pair.
- All travellers are assigned to one particular route and none to others.

- **Step 1**
  Find the shortest route between the TAZs
- **Step 2**
  Assign all trips to links comprising the shortest route
- **Step 3**
  Continue until trips between all TAZs pairs have been assigned
2. Multipath Assignment:

- In essence, the all-or-nothing assignment assumes that all trips-maker’s traveling between a specific pair of zones actually select the same path. In reality, however, interchange volumes are divided among a number of paths.

- Algorithms that are capable of determining several paths between each pair of zones in order of increasing impedance are available. Irwin and Von Cube formula:

  \[ P(r) = \frac{W_{ijr}^{-1}}{\sum_x W_{ixr}^{-1}} \]

  Where \( W_{ijr}^{-1} \) is impedance of route \( r \) from \( i \) to \( j \).
3.2. The supply side of transportation: the modes, their roles and characteristics [capacity, cost etc.]

- Transportation demand and Transportation Supply
- Here we discuss about Transportation supply planning process
- Transportation supply refers to Transportation network, facilities and services (vehicles and their frequency) and their characteristics.
- Supply is expressed in terms of Infrastructures (capacity), services (frequency) and network (coverage). Capacity is often assessed in static and dynamic terms.
- The number of passengers, volume (for liquids or containerized traffic) or mass (for freight) that can be transported per unit of time and space is commonly used to quantify transport supply.
- Passenger-Km (Passenger-mile) and ton-km (or ton-mile) is a common measure expressing the realized passenger and freight transport demand (as well as supply) respectively.
Performance and Cost

Demand and supply are inherently linked together.

Higher the demand higher will be the supply side.

Demand for transportation, measure of performance, impacts and costs are important evaluation criteria for selection of best or most appropriate alternative or proposal from the bundle of alternatives.

Evaluation of various alternatives are considered based on Measures of Effectiveness (MoE) which includes efficiency, equity, feasibility, adequacy, financial analysis etc.
The estimation of current and forecasted system performance, impact and cost characteristics leads to the identification of project alternatives and after the evaluation process we came with the most appropriate solution, policies or strategies to meet the present demand.

Reflect the trend toward continual monitoring of transportation system performance.

The feedback from both demand and supply analysis is used to determine where deficiencies exist in the transportation network that can then lead to the identification of strategies for solving potential problems.

The cycle goes on and on.

Role of supply analysis for transport analysis

Metropolitan level of network analysis for strategic investment:

Operational and tactical planning:

Scheduling of transportation services:
3.3. Other recent approaches to transportation planning

- Transporting Planning is the process of defining future polices, goals, investments and design to prepare for future needs to move people and goods to destinations.
- It is a collaborative process that incorporates the input of many stakeholders including various government agencies, the public and private businesses.
- Transport planners apply a multimodal and/or comprehensive approach to analyzing the wide range of alternative and impact on the transportation system to influence beneficial outcomes.
- It is involved with the evaluation, assessment, design and siting of transport facilities (generally streets, highway, bike lanes and public transport lines)
- Transport planning has historically followed the rational planning model of defining goals and objectives, identifying problems, generating alternatives, evaluating alternatives, and developing plans.
Other models for planning

1. Rational actor

   Rational choice theory, also known as choice theory or rational action theory is a framework for understanding and often formally modeling social and economic behavior.
2. Transit oriented development

- A transit oriented development (TOD) is a mixed use residential and commercial area designed to maximize access to public transport, and often incorporates features to encourage transit ridership.

- A TOD neighborhood typically has a center with a transit station or stop (train station, metro station, tram stop or bus stop), surrounded by relatively high-density development with progressively lower density development spreading outward from the center.

- TODs generally are located within a radius of one-quarter to one half mile (400 to 800m) from a transit stop, as this is considered to be an appropriate scale for pedestrians, thus solving the last mile problem.

3. Satisficing

Satisficing is a decision-making strategy that entails searching through the available alternatives until an acceptability threshold is met.

4. Incremental Planning

It is a method of working by adding to a project using many small incremental changes instead of a few (extensively planned) large jumps.
5. Organizational process

The process include the organizational behavior which is the study of human behavior in organizational setting, the interface human behavior and organization and the organization itself.

It can be divided in three levels:
- Individual in Organizations (micro-level).
- Work groups (meso-level),
- How organizations behave (macro-level)

6. Political bargaining

- This process include Public choice or public choice theory which refers to “the use of economic tools to deal with traditional problems of political science.
- In political science, it is the subset of positive political theory that studies self-interested agents (voters, politicians, bureaucrats) and their interactions, which can be represented in a number of ways - using (e.g.) standard constrained utility maximization, game theory, or decision theory.
THE END