Hardware Requirements and Running Time for the MORPC Travel Forecasting Model

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Introduction

In October 2001, the Mid-Ohio Regional Planning Commission (MORPC) contracted with PB Consult to develop a new set of regional travel forecasting models. The new model is a disaggregate tour-based model applied with the micro-simulation of each individual household, person or tour. The new modeling system was completed in late 2004 and refined throughout 2005. The new model is being used by MORPC for Conformity Analysis, transit alternative analysis, and for highway MIS projects in the Columbus region.

The model area is divided into 1805 internal and 72 external zones and includes Franklin, Delaware, and Licking counties, and parts of Fairfield, Pickaway, Madison and Union counties. The primary inputs to the model are transportation networks and zonal data, where each zone has the standard socioeconomic characteristics that one would normally find in a four-step model. The main differences from the prior four-step model are that the new model accounts for travel at the tour-level, as opposed to the trip-level, and for each individual household and person, as opposed to zonal and market segment aggregates.

Model Formulation

The forecasting model consists of nine separate linked models and other network processing steps. The nine models are:

1. Population Synthesis - A synthesized list of all households and population for the entire area is generated, consistent with the household and workforce variables in the zonal data. The output from the Population Synthesis model is a file with a record for every person in the area containing various attributes attributed to that synthesized person.
2. Auto Ownership - The number of vehicles available for each household is simulated.
3. Daily Activity Pattern - The Daily Activity Pattern for each person and the number of mandatory tours each person with a mandatory activity pattern makes during the day are simulated.
4. Joint Tour Generation – generation of tours undertaken by members of the same household
5. Individual Non-Mandatory Tour Generation

6-8. Tour Destination Choice, Time of Day Choice, and Tour Mode Choice – logit based choice models that are applied together

9. Stops and Trip Mode Choice - This model determines if any stops are made on either the outbound (from home), or inbound leg of the tour and the location of those stops.

The core choice models (1 through 9 as described above) are applied in a disaggregate manner. Instead of applying aggregate fractional probabilities to estimate the number of trips, the new model is applied with the micro-simulation of each individual household, person, or tour, mostly using Monte Carlo realization of each possibility estimated by the models, with use of a random number series to determine which possibility is chosen for that record.

The new model is implemented with three global feed back loops for consistency between highway travel times that are both used as inputs to, and as forecast outputs of the model.

The main model application package is Cube, with TP+ being used for network management, assignment, external and commercial vehicle models and other processing. The core tour-based choice models described above are written in Java with access to the TP+ skims. The custom programs are designed to take advantage of the numerous opportunities for parallel processing in the model chain, multi-threading of tasks, and to readily accommodate the addition of computers in the distributive processing framework to optimize processing.

After the networks and initial skims are generated in TP+ and all input files are created for a particular scenario, the custom Java programs are executed to implement the tour-based microsimulation models. A pre-assignment processor step aggregates the microsimulation results and integrates the commercial and external models to produce standard TP+ trip tables for four time periods. After the final trip tables are generated, vehicles are assigned with a multi-class (SOV, HOV, Medium Truck and Heavy Truck) equilibrium assignment utilizing 21 Volume Delay Functions by facility and area type for each of four time periods (AM, Midday, PM, and Night). Transit assignments are also performed in TP+ for the AM and Midday time periods, with standard reports generated to support analysis and evaluation of the alternatives tested. (See Anderson et al for further discussion.)

Hardware Configurations

There are currently three operational systems that can run the MORPC travel forecasting model. The two systems that are currently installed at MORPC are the topic of this paper. The initial system was built in December 2004 with one Server computer and three Worker computers. The specifications for the computers are below.

- Server
  - Dual 64bit Xeon 3.6 GHz 1MB L2 800MHz FSB Processors
  - 4 GB PC3200 ECC Registered DDR Memory
  - 4 - 36GB SCSI 15K U320 RAID-5 Array
  - Dual Gigabit network interface cards
  - Windows 2000 Server OS
- Worker (3-4)
  - Dual Xeon 3.06 GHz 512KB L2 533MHz FSB
  - 2 GB PC2100 ECC Registered DDR Memory
  - 120 GB IDE HDD
  - Gigabit network interface card
  - Linux 32-bit OS

- Networking Specifications
    - 5 port 10/100/1000 Gigabit network switch
    - CAT6 Ethernet cable

The Workers are directly networked and are isolated from the general MORPC network to make them less susceptible to viruses. The Workers are not running anti-virus software every time a file is accessed, unlike the rest of the MORPC network; it was found that running anti-virus software imposed a 15% penalty on the run time. In December 2005, a fourth Worker was added to the cluster. This first system is running 32 bit Operating Systems and Java.

The second system was purchased by the Central Ohio Transit Authority (COTA) in support of their North Corridor Transit Project DEIS. This cluster consists of one Server and four Workers all running 64 bit Windows and Java. The specifications for this cluster are below.

- Server
    - Dual 64 bit AMD Opteron 2.2 GHz 1MB L2 Cache Processors
    - 4 GB PC3200 ECC Registered DDR Memory
    - 4 - 73GB SCSI U320 10K RPM RAID-5 Array
    - Dual Gigabit network interface cards
    - Windows 2003 Server 64 bit OS
- Worker (4)
    - Dual 64 bit AMD Opteron 2.2 GHz 1MB L2 Cache Processors
    - 4 GB PC3200 ECC Registered DDR Memory
    - 160 GB SATA NCQ HDD
    - Dual Gigabit network interface card
    - Windows XP Professional 64 bit OS

Model Running Times

Table 1 shows the running times of the MORPC Travel Forecasting Model for 2000 and 2030 on the various computer systems. *MORPC 3* is the MORPC system with three Linux Workers running 32 bit Operating Systems (OSs), *MORPC 4* is the MORPC system with four Linux Workers running 32 bit OSs, and *COTA* is the COTA system with four Windows XP Workers running 64 bit OSs. 2000 has 1.5 million synthetic people making 2 million tours; 2030 has 2 million synthetic people making 3 million tours. All runs include only 2 transit modes (local and express bus). The Core Model running time does not include the time to generate the four period highway networks, two period transit networks including support links, or the time to generate the initial travel skims, which is similar to the time to generate the travel skims during the model run. Overall, the time for these excluded tasks is about 2 hours of running time on a 32 bit Windows computer.

Times for the individual model components are shown for Iteration 1. At the end of Iterations 1 and 2, the AM and Midday Highway trips are assigned and the congested networks are then skimmed for feedback to the next iteration. PM and Night skims are the transposed AM and Midday skims. At the end of the third iteration, all highway and transit trips are assigned to the appropriate network.

Table 1: 2000 and 2030 Running Times of the MORPC Travel Models (Hour:Min)

	2000			2030		
	MORPC 3	MORPC 4	COTA	MORPC 3	MORPC 4	COTA
Households	610,774	610,774	610,774	872,919	872,919	872,919
Population	1,435,389	1,435,389	1,435,389	1,956,660	1,956,660	1,956,660
Tours	2,074,618	2,073,659	2,075,797	2,997,507	2,997,214	2,996,117
Core Model Total (3 iterations)	35:43	31:20	20:55	48:35	41:23	26:43
Iteration 1	11:27	10:08	6:51	16:18	13:28	8:30
Iteration 2	11:26	9:55	6:28	14:59	12:48	8:06
Iteration 3	12:49	11:16	7:36	17:17	15:06	10:06
Iter 1 - Population Synthesis	0:02	0:02	0:01	0:02	0:02	0:01
Iter 1 - Sending Files to Workers	0:20	0:20	0:12	0:19	0:20	0:14
Iter 1 - Auto Ownership	0:01	0:01	0:00	0:02	0:02	0:01
Iter 1 - Mandatory Tour Generation	0:53	0:53	0:39	1:15	1:15	0:39
Iter 1 - Mandatory DTM	4:01	3:14	1:59	6:07	4:48	2:50
Iter 1 - Joint Tour Generation	0:12	0:12	0:08	0:14	0:14	0:08
Iter 1 - Joint Tour DTM	0:08	0:06	0:04	0:08	0:07	0:05
Iter 1 - Individual Tour Generation	0:05	0:05	0:05	0:07	0:07	0:05
Iter 1 - Individual Tour DTM	0:54	0:41	0:23	1:15	0:56	0:30
Iter 1 - At-Work Sub-Tour DTM	0:08	0:07	0:06	0:12	0:10	0:07
Iter 1 - Mandatory Stops Model	0:49	0:38	0:21	1:14	0:59	0:32
Iter 1 - Joint Stops Model	0:07	0:06	0:04	0:08	0:07	0:05
Iter 1 - Individual Stops Model	0:54	0:43	0:24	1:11	0:54	0:31
Iter 1 - At-Work Stops Model	0:06	0:05	0:04	0:09	0:08	0:05
Iter 1 - Writing Files and Trip Tables	0:13	0:13	0:10	0:35	0:34	0:26
Iter 1 - External Model +	0:00	0:00	0:00	0:01	0:01	0:01
Iter 1 - Commercial Vehicle +	0:02	0:02	0:01	0:02	0:02	0:01
Iter 1 - IE Trips +	0:00	0:00	0:00	0:00	0:00	0:00
Iter 1 - Highway Assignment - 2 period +	1:08	1:14	1:07	2:03	1:31	1:16
Iter 1 - Highway and Transit Network Skimming +	1:17	1:17	0:53	1:04	1:03	0:44
Iter 3 - Highway Assignment - 4 period +	2:14	2:18	1:51	3:11	3:07	2:19
Iter 3 - Transit Assignment - 2 period +	0:16	0:16	0:10	0:12	0:12	0:07

DTM = Destination, Time of Day, and Mode Choice
+ = Run with TP+ on Server

As seen from Table 1, 2030 takes longer to run than 2000 due to the additional population and tours. The addition of the fourth Worker on the MORPC system improves the running time on the DTM and Stops models. The COTA system shows the most significant improvement in running times due to 64 bit computing and runs substantially faster than the 32 bit MORPC system. Therefore, any future installations of the MORPC model system would almost certainly involve 64 bit computing.

All run times are based on Cube Version 3.2. All TP+ programs are run on the Server in sequential order. It has been found that Windows will only allocate a maximum of 50% of its CPU power to any one application. Therefore, if the TP+ scripts were run in parallel, a significant time savings could result. Future upgrades include installing Cube on the Workers of the COTA system and sending TP+ scripts to run in parallel on the Workers. This is not possible on the MORPC system as the Workers are running Linux.

MORPC Modeling Staff

MORPC employs three staff members who use the travel forecasting model directly. Responsibilities are broken down roughly as follows:

Senior Engineer – This person manages the model development and is familiar with the theory behind the model. This person runs the model for projects when needed and would proffer new features to be added to the model. This job includes model validation and calibration and script writing in support thereof.

Associate Engineers (2) – These people run the model for project level analysis and air quality conformity. They maintain and upgrade the highway and transit networks.

In addition to the staff above, MORPC employs five staff members who maintain and forecast the socio-economic variables and two others who use the model results.

The Ohio Department of Transportation (ODOT) provides assistance for model development and running the model upon request by the MPOs. ODOT also runs the model for its own studies and projects.

Post Script

The ODOT system is expected to be operation in mid to late 2006. Run times will be made available in late 2006 upon request.

References

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PB Consult, *MORPC Travel Forecasting Model – Systems Documentation*, Draft December 2004