

Mode-to-Mode Transfers with the EMME/2 Transit Assignment: Flows and Fares

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Oct. 19-21, 2005, Seattle, USA

19th Annual International EMME/2 Users Conference

Motivation:

- Consider transit mode-to-mode transfer penalties (fares) in the transit assignment, which may be:
 - transfer fare for mode-to-mode movements;
 - other costs related with the mode-to-mode transfers.
- Obtain the volume of transfers between different modes at specific nodes such as transfer centers, metro stations.
- Previous work by Heinz Spiess:
 - Computing Line-to-Line Transfer Matrices With EMME/2

Brief Review of Heinz's Work

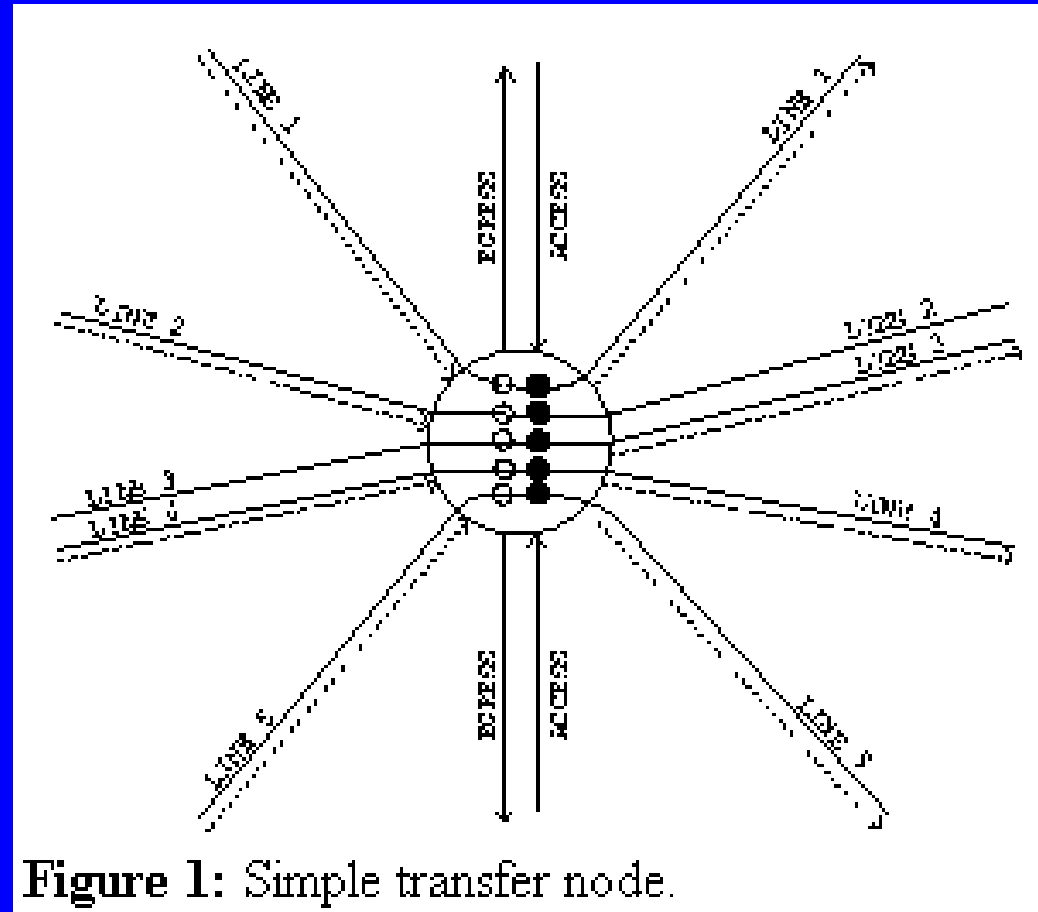


Figure 1: Simple transfer node.

Brief Review of Heinz's Work

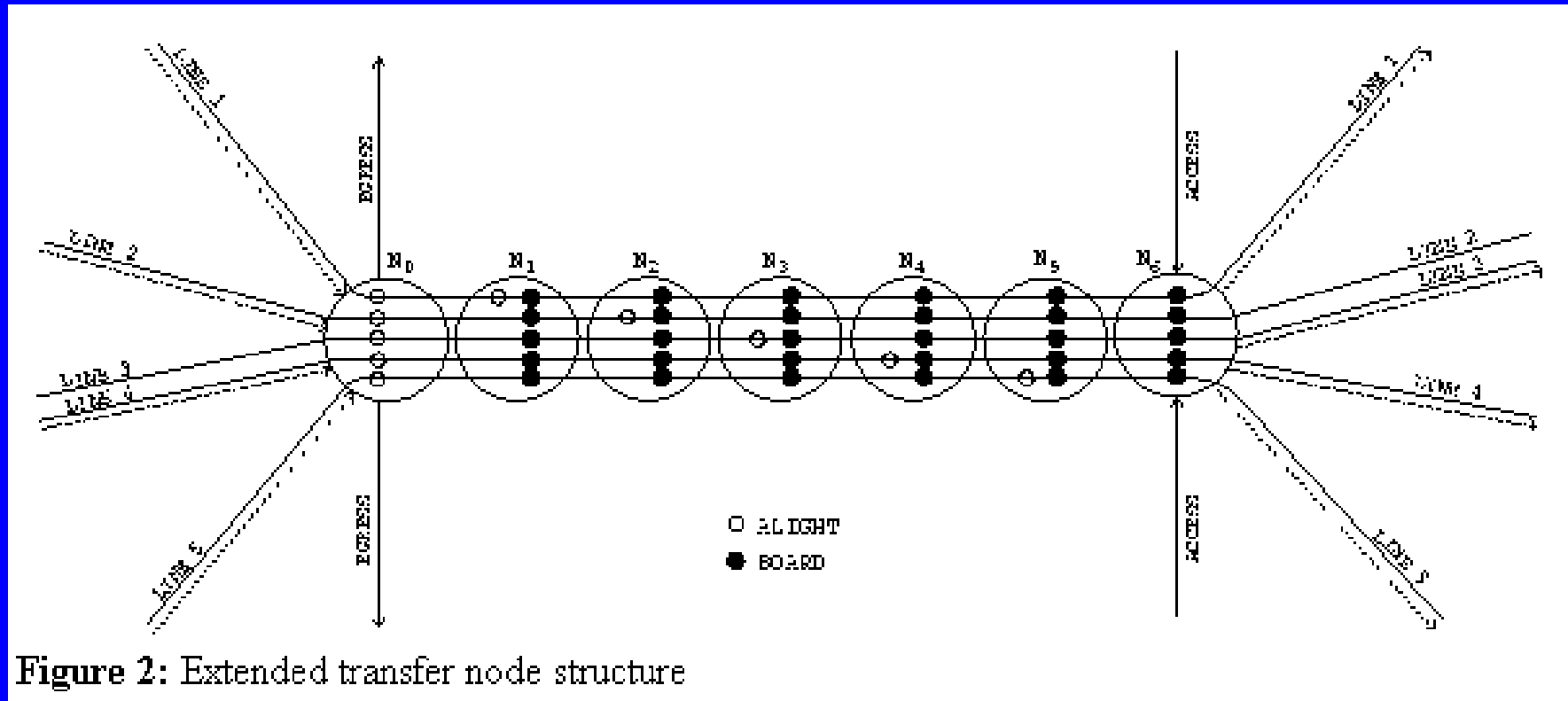


Figure 2: Extended transfer node structure

Brief Review of Heinz's Work

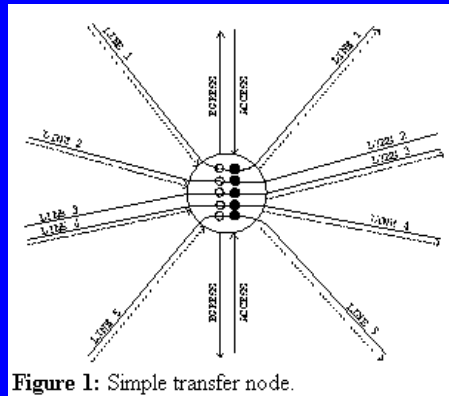


Figure 1: Simple transfer node.

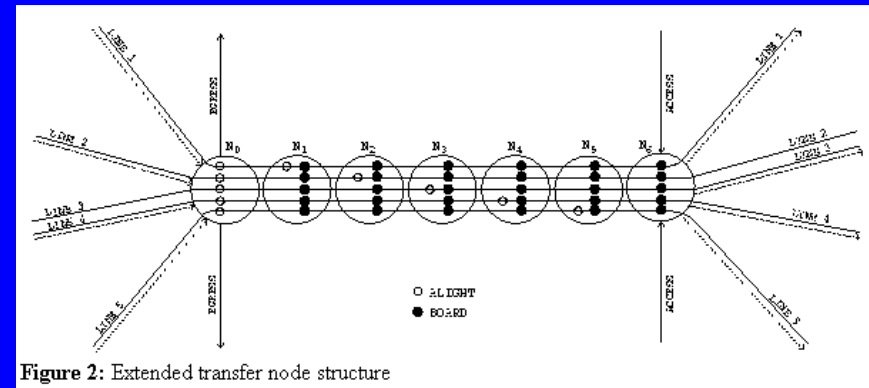
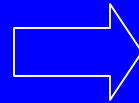


Figure 2: Extended transfer node structure

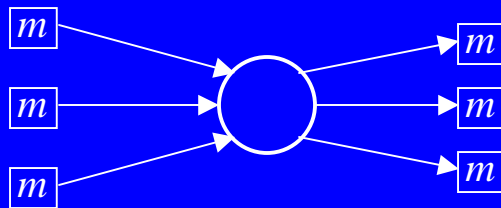
- The route choice is not changed by this node expansion since the waiting times at the node are not changed;
- The line-to-line transfer volume appears as boarding or alighting at the dummy node;

<http://www.spiess.ch/emme2/transfer/transfer.html>

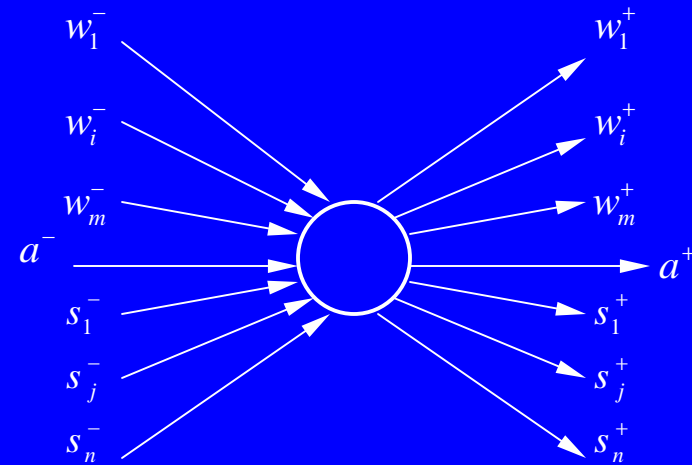
Mode-to-Mode Transfer with Penalties:

- In order to consider the mode-to-mode transfer with penalties, one needs
 - to make a different expansion of the node;
 - to compute aggregated information at the mode-to-mode level of detail, instead of at the line-to-line level of detail.

A Node Before Expansion



A different view



A node and links of a base network, where one link has several modes defined;

m is a subset of all the set of modes M . $m \subseteq M$

Where

w_i are walk links of mode i , $w_i \subseteq W$, $i = 1 \dots m$

w_i^+ are walk links of mode i outgoing from the node

w_i^- are walk links of mode i incoming to the node

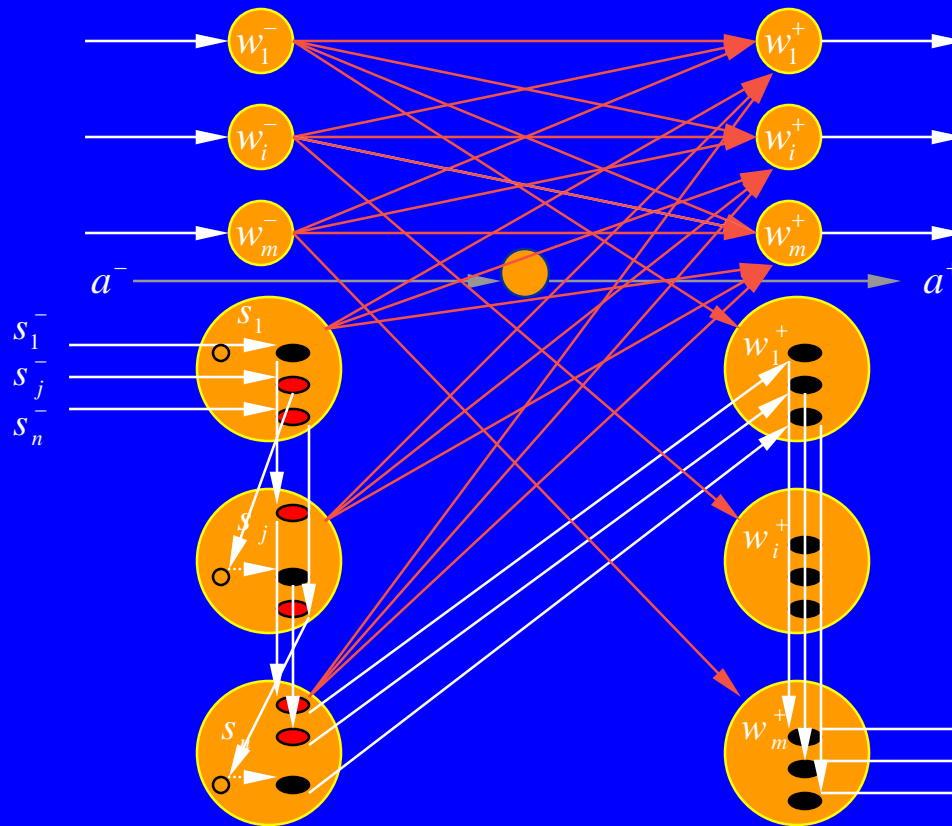
s_j are transit segments of mode j , $s_j \subseteq S$, $j = 1 \dots n$

s_j^+ are transit segments of mode j outgoing from the node

s_j^- are transit segments of mode j incoming to the node

a^-, a^+ are the links of the car (auto) mode

Desired Node Expansion



max. number of new nodes:

$$3m+n$$

max. number of new links:

$$(m^2+2m)+m*n+n$$

max. number of new segments:

$$((m-1)+(n-1)+1)*\text{number of transit lines}$$

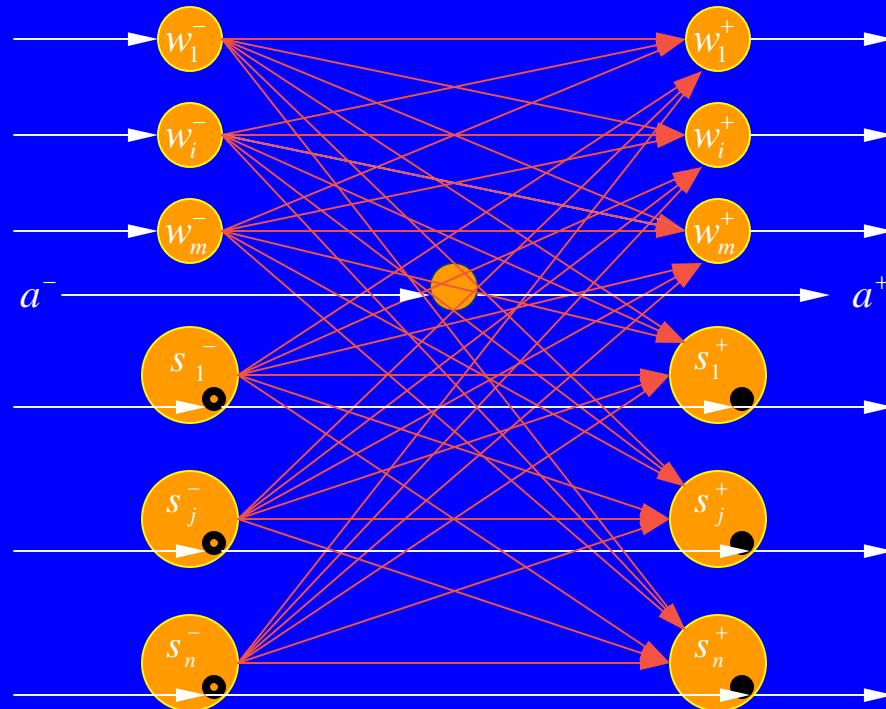
where:

m is the number of walk modes

n is the number of transit segments (lines)

- Waiting times are preserved and so is the route choice;
- Penalties and transfer flows on *red* links for transfers to and from walk modes;
- Penalties and transfers flows on *boarding* for transfers between transit modes.
We need to put node boarding penalties of a line. How? Not yet in EMME/2.

Actual Node Expansion



max. number of new nodes:

$$2(m+n)$$

max. number of new links:

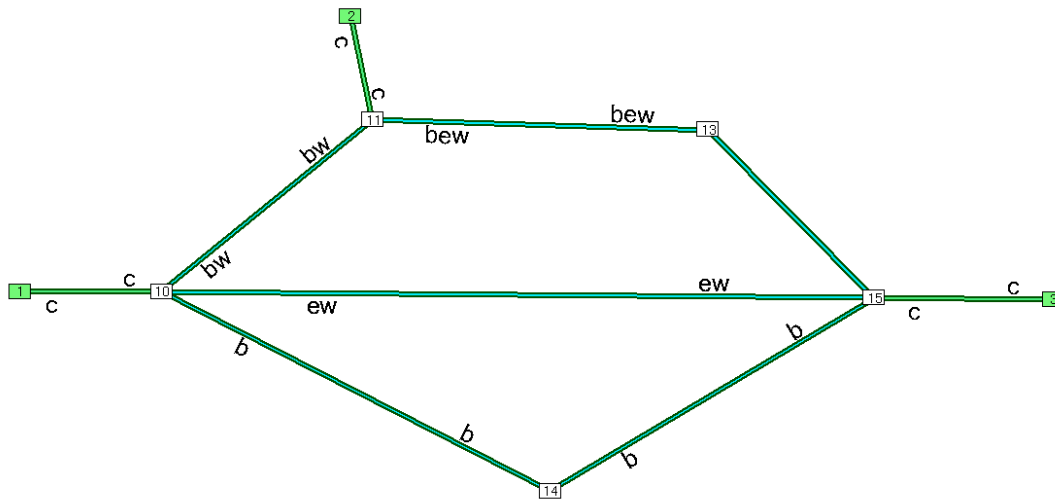
$$(m+n)^2$$

max. number of new segments:

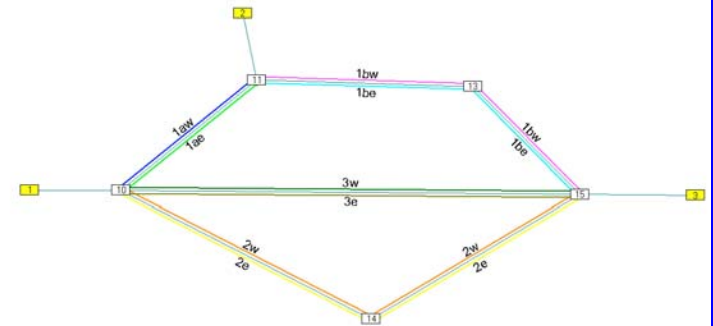
number of transit lines

- Penalties and transfer flows on *red* links for transfers between modes;
- Waiting times are *NOT* preserved when compared to the original network.

A Small Example



Base network



Transit network

c Mode-to-mode transfer penalty (fare) table.

t mode-to-mode cw be

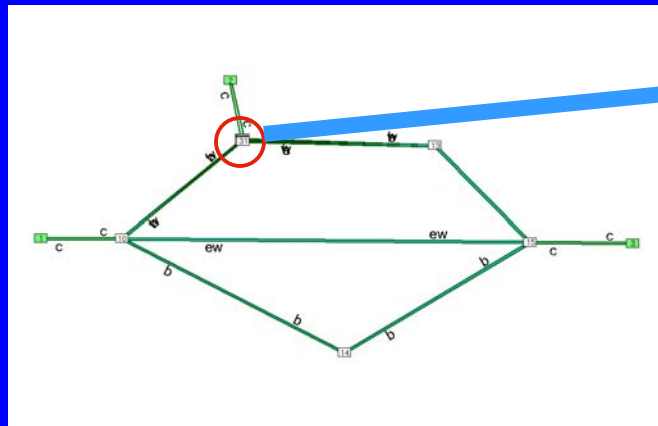
c	c	w	b	e	
a	c	0	-	1.5	2.0
a	w	-	0	1.3	2.2
a	b	0	0	0	1.0
a	e	0	0	0.5	0

Where:

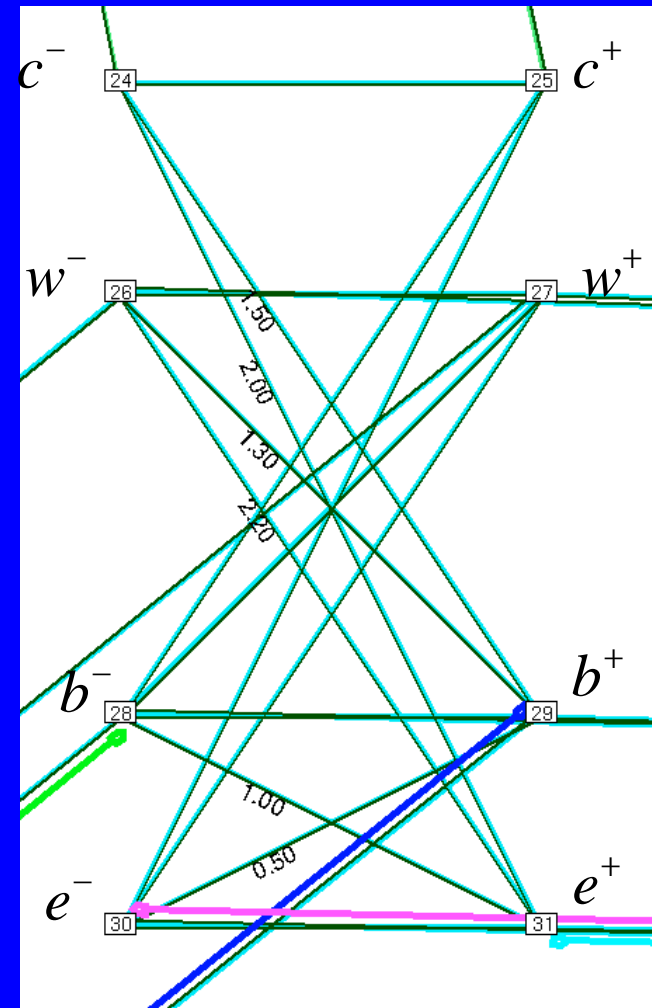
c and w are walk modes

b and e are transit modes

Expansion of Node 11

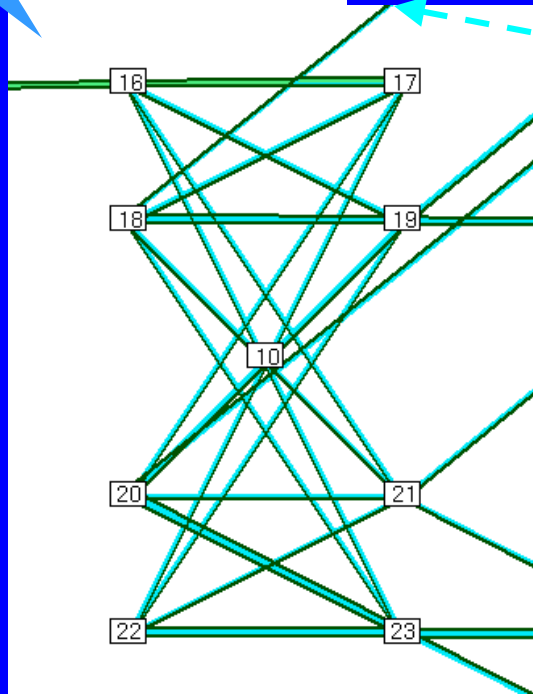
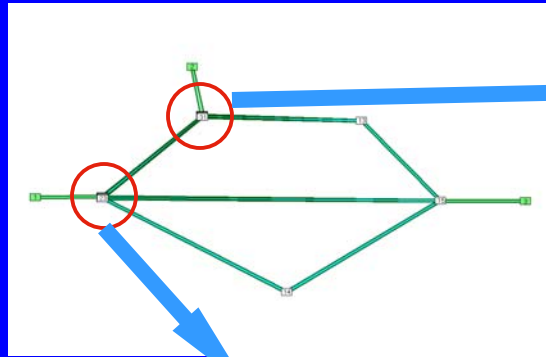


Expanded base network for node 11

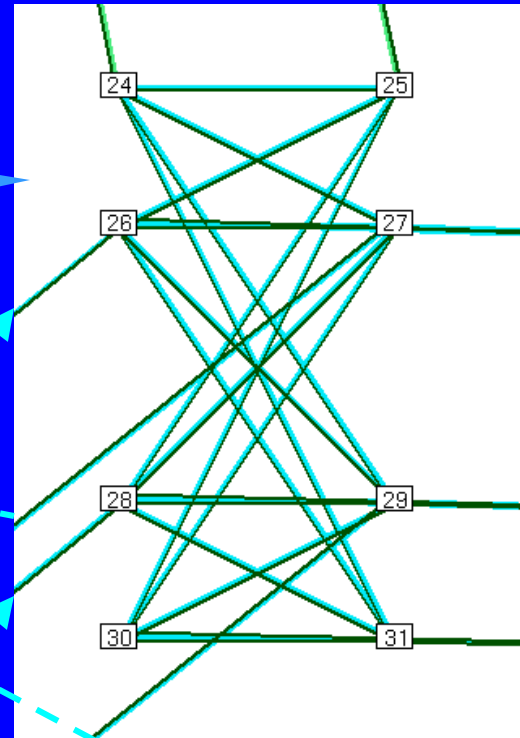


Zoom in of expanded node 11

Expansion of Nodes 10 and 11



Zoom in of expanded node 10

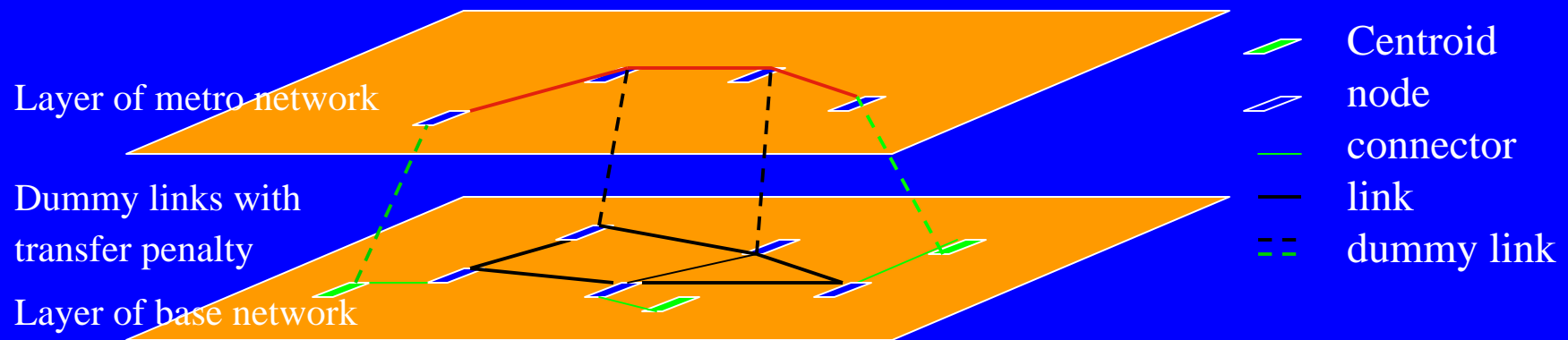


Zoom in of expanded node 11

w

b

Expansion of All the Nodes of a Metro Line:



After all nodes of a metro line are expanded:

- the metro line has its layer;
- layers are connected with dummy links;
- dummy link has transfer penalties;
- volume on the dummy links are the transfer flows between modes.

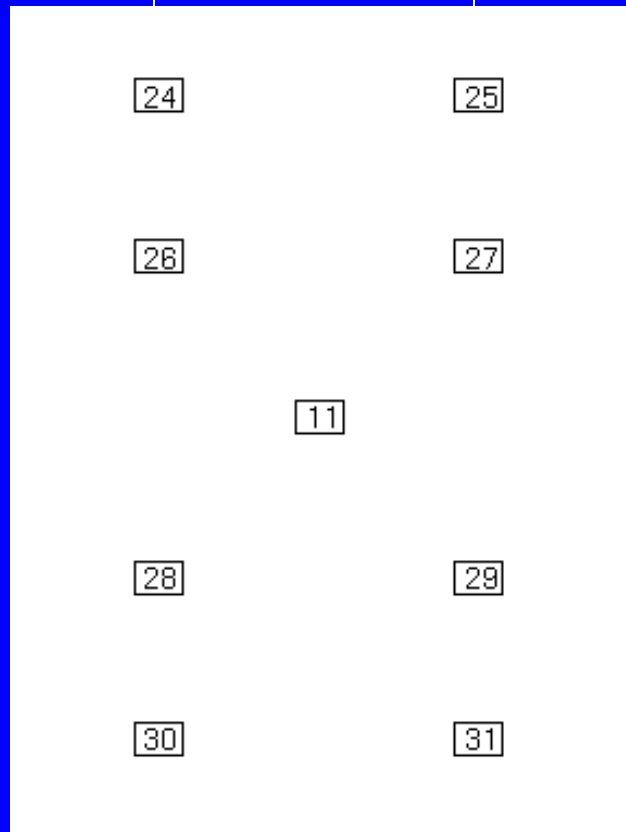
Implementation in an EMME/2 Macro

node number and its location

node for
incoming
link

node for
outgoing
link

Any new node and its location are known
for the given original node.



node for the first walk mode

node for the second walk mode

original node and location

node for the first transit mode

node for the second transit mode

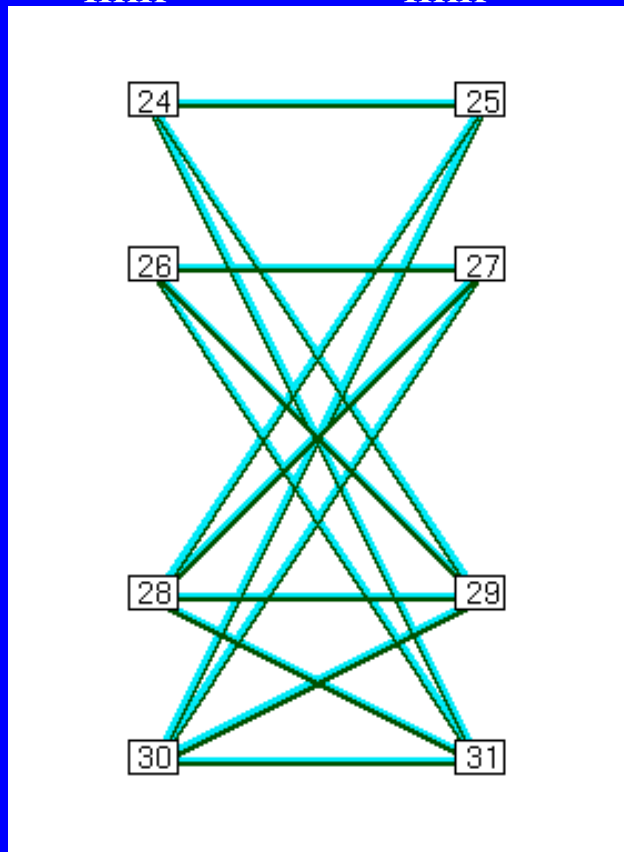
Implementation in an EMME/2 Macro

dummy link and its penalty (volume)

node for
incoming
link

node for
outgoing
link

Any link and its penalty (volume) are known for the given dummy nodes.



node for the first walk mode

node for the second walk mode

node for the first transit mode

node for the second transit mode

Implementation of the EMME/2 Macro

description of the implementation steps

1. Copy the network to be expanded into a new scenario;
2. Add an aux. transit mode, e.g. *z*, to the mode table, with cost equal to *ul1/walk weights*;
3. Add a dummy function, e.g. *ft9=0*, for the transit segment time on the dummy links;
4. Read the mode-to-mode transfer penalty table, *m2mtras.in*, and save it in *ms101, ms102, ...*;
5. Find the starting dummy node number (based on the max., min. node number, and a node number given by user);
6. Find the node coordinate shift, delta *x* and delta *y*;
7. Punch out the coordinates of the node that are expanded: *node coordinate file*;

Implementation of the EMME/2 Macro

description of the implementation steps

8. Read a node from the node coordinate file;
9. Batch out the links and transit lines connected with the node;
10. Create a batchin file for dummy nodes;
11. Create a batchin file for new and modified links, and links with auto modes;
12. Create a batchin file for updating new transit lines using dummy nodes and links;
13. Update data in the databank for nodes, links, lines and link attributes if needed;
14. Back to step 8 for reading the next node until all the required nodes are expanded;
15. Update node attributes for dummy nodes if needed;
16. Carry on transit assignments as usual and make reports to the screen and the file.

Usage of the EMME/2 Macro: *m2mtras.mac*

usage 1: nodes expansion

```
~/**  USAGE 1: ~<m2mtras.mac <s1> <s2> <demand> <nodes> [node gap] **
~/**                                     [btim] [ww] [aw] [bw] [flag] **
~/**  where <s1> original network scenario **
~/**          <s2> new scenario with mode transfer penalties **
~/**          <demand> transit trip demand for the assignment **
~/**          <nodes> current node list for expansion, **
~/**                      eg. 11 for node 11 only, or **
~/**                      11,14 for nodes from 11 to 14, or **
~/**                      11;13;15 for node 11, 13 and 15 **
~/**          a node attribute (>0), eg. @m2m. t1 **
~/**  [node gap] default= 0, the node number gap between **
~/**          the max. node and the possible min. dummy node. **
~/**          [btim] boarding time, r3, optional (default=2.5) **
~/**          [ww] waiting time weight, r4, optional (default=2.0) **
~/**          [aw] auxiliary time weight, r5, optional (default=2.0) **
~/**          [bw] boarding time weight, r6, optional (default=2.0) **
~/**          [flag] 0 or empty, full operation r90 **
~/**          1, expanding nodes only (no assignments, results) **
~/**          2, expanding nodes, assignment and summary results**
```

Usage of the EMME/2 Macro: *m2mtras.mac* mode-to-mode transfer table: *m2mtras.in*

```
~/**      - mode to mode transfer penalty input file: m2mtras.in      **
~/**      format:                                                    **
~/**      t mode-to-mode <walk modes> <transit modes>              **
~/**      a <mode> penalty penalty ...                               **
~/**      eg.                                                         **
~/**      t mode-to-mode cw be                                       **
~/**      c          c          w          b          e               **
~/**      a  c      0          -          1.5        2.0             **
~/**      a  w      -          0          1.3        2.2             **
~/**      a  b      0          0          0          1.0             **
~/**      a  e      0          0          0.5        0               **
~/**      where cw is the walk mode string, be is the transit      **
~/**      -, or any number > 999 means no-transfers                **
```

Usage of the EMME/2 Macro: *m2mtras.mac* usage 1b: more nodes expansion

- Suppose we have expanded the node 11, with

```
~<m2mtras.mac 1000 6000 mf1 11
```
- We can add another node (10) expansion on the it, by runing

```
~<m2mtras.mac 6000 7000 mf1 10
```

where *1000* is the original scenario;
6000 is the scenario with node 11 expanded;
7000 is the scenario with node 10 and 11 expanded.
- To get the scenario *7000* directly, run,

```
~<m2mtras.mac 1000 7000 mf1 10;11
```

Usage of the EMME/2 Macro: *m2mtras.mac*

usage 2: assignment and reports only

```
~/**  USAGE 2: ~<m2mtras.mac [NoExpansion] [flag] **
~/**      [NoExpansion]If the first argument is non-numerical, **
~/**          it will NOT do node expanding, but read **
~/**          information from the former output file **
~/**          m2mtras.rpt, and append the results. **
~/**      [flag] 0 or empty, assignment and all results, r90 **
~/**          2, assignment and summary results **
~/**          3, results only **
~/**          4, summary results only **
```

Results of the EMME/2 Macro: *m2mtras.mac* report file: *m2mtras.rpt*

```
===== TRANSIT ASSIGNMENT WITH MODE-TO-MODE TRANSFER PENALTIES =====  
Macro arguments:          1000 6000 mf1 11 0 1 1 1 1 2  
Date:                    30522  
Original Scenario:       1000  
Working Scenario:        6000  
Transit Demand:          mf1  
Node(s) for M2M Transfers: 11  
Dummy Mode for Transfers: z  
Dummy Transit Function:  ft9=0  
Walk (aux. transit) Modes: cw  
Transit Modes:           be  
Mode-to-Mode Penalties in: ms101 - ms116  
Node Number Base:        -64  
  dummy node range:      16 64  
Node Number Factor:      8  
Boarding Time:           1  
Waiting Time Weight:     1  
Aux. Transit Time Weight: 1  
Boarding Time Weight:    1
```

Results of the EMME/2 Macro: *m2mtras.mac* report file: *m2mtras.rpt* (continue)

Transfers (ex. volumes on the same line) on node: 10

M2M	c	w	b	e
c--	.00 (.00)	--- (-)	400.00 (1.50)	.00 (2.00)
w--	--- (-)	.00 (.00)	.00 (1.30)	.00 (2.20)
b--	362.50 (.00)	.00 (.00)	.00 (.00)	.00 (1.00)
e--	37.50 (.00)	.00 (.00)	.00 (.50)	.00 (.00)

Transfers (ex. volumes on the same line) on node: 11

M2M	c	w	b	e
c--	.00 (.00)	--- (-)	100.00 (1.50)	1300.00 (2.00)
w--	--- (-)	.00 (.00)	.00 (1.30)	.00 (2.20)
b--	100.00 (.00)	.00 (.00)	.00 (.00)	225.00 (1.00)
e--	1300.00 (.00)	.00 (.00)	187.50 (.50)	.00 (.00)

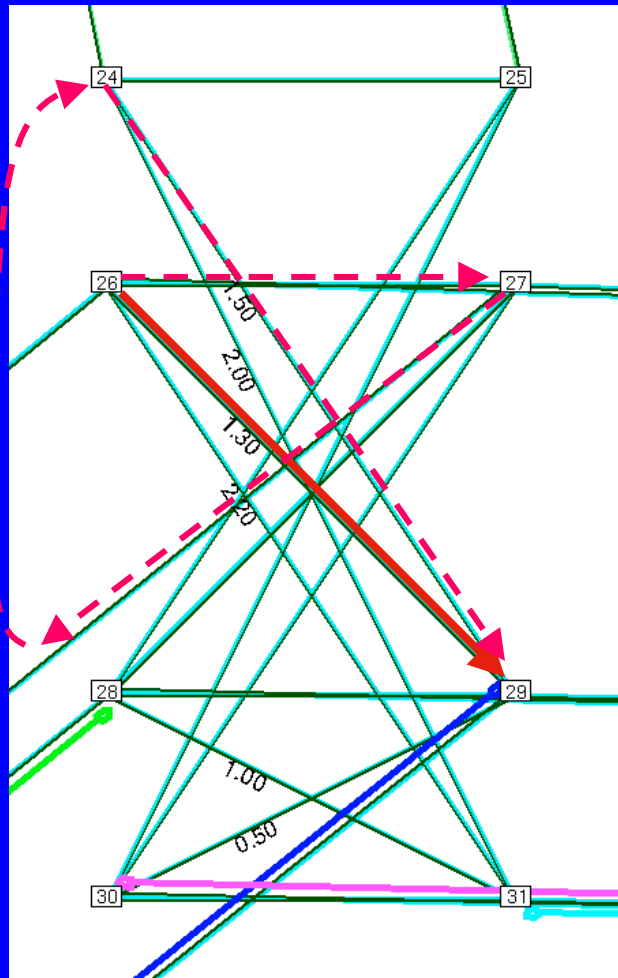
Transfer summary on all nodes:

=====

M2M	c	w	b	e
c--	0 (.00)	--- (-)	500 (1.50)	1300 (2.00)
w--	--- (-)	0 (.00)	0 (1.30)	0 (2.20)
b--	463 (.00)	0 (.00)	0 (.00)	225 (1.00)
e--	1338 (.00)	0 (.00)	188 (.50)	0 (.00)

Discussion of Some Necessary Conditions

- Transfer costs should be small enough.



E.g. the direct transfer costs from node 24 to node 29 (→) should be less than that of any possible path (-→) going out of the node system expanded.

Cautions and Discussions (continue)

- To compare results with and without transfer fare scheme, the nodes should be expanded and compare the results between zero fare and the fare proposed. That is,

- run the macro for zero fare (in one scenario);

```
~<m2mtras.mac 1000 6000 mf1 @m2m
```

t	mode-to-mode	cw	be		
c	c	w	b	e	
a	c	0	-	0	0
a	w	-	0	0	0
a	b	0	0	0	0
a	e	0	0	0	0

- then run the macro again for the fare scheme (in another scenario).

```
~<m2mtras.mac 1000 6001 mf1 @m2m
```

t	mode-to-mode	cw	be		
c	c	w	b	e	
a	c	0	-	1.5	2.0
a	w	-	0	1.3	2.2
a	b	0	0	0	1.0
a	e	0	0	0.5	0

Conclusions

- Mode-to-mode transfer penalties can be considered in the EMME/2 transit assignments by expanding the nodes;
- Mode-to-mode transfer volumes can be obtained at the same time;
- The process is fully automated by running only one macro;
- The output results are easy to interpret;
- Users should be careful with the network dimensions and scale dimension (*ms100+* are used.);