

Ruta para el 1er. y 2do. Turno

$$\begin{aligned} \text{MIN} = & 520 * X_1 * N_1 + 521 * X_2 * N_2 + 500 * X_3 * N_3 + 501 * X_4 * N_4 + 450 * X_5 * N_5 + 565 * X_6 * N_6 + 800 * X_7 * N_7 \\ & + X_8 * N_2 + 20 * X_9 * N_3 + 21 * X_{10} * N_4 + 418 * X_{11} * N_5 + 533 * X_{12} * N_6 + 1217 * X_{13} * N_7 + X_{14} * N_1 + 41 * X_{15} * N_3 \\ & + 42 * X_{16} * N_4 + 419 * X_{17} * N_5 + 534 * X_{18} * N_6 + 1218 * X_{19} * N_7 + 40 * X_{20} * N_1 + 41 * X_{21} * N_2 + X_{22} * N_4 \\ & + 398 * X_{23} * N_5 + 513 * X_{24} * N_6 + 1197 * X_{25} * N_7 + 41 * X_{26} * N_1 + 42 * X_{27} * N_2 + X_{28} * N_3 + 399 * X_{29} * N_5 \\ & + 514 * X_{30} * N_6 + 1198 * X_{31} * N_7 + 418 * X_{32} * N_1 + 419 * X_{33} * N_2 + 398 * X_{34} * N_3 + 399 * X_{35} * N_4 + 115 * X_{36} * N_6 \\ & + 998 * X_{37} * N_7 + 533 * X_{38} * N_1 + 534 * X_{39} * N_2 + 513 * X_{40} * N_3 + 514 * X_{41} * N_4 + 115 * X_{42} * N_5 \\ & + 1113 * X_{43} * N_7 + 1217 * X_{44} * N_1 + 1218 * X_{45} * N_2 + 1197 * X_{46} * N_3 + 1198 * X_{47} * N_4 + 998 * X_{48} * N_5 + 1113 * X_{49} * N_6 \\ & + 520 * X_{50} + 521 * X_{51} + 500 * X_{52} + 501 * X_{53} + 450 * X_{54} + 565 * X_{55} + 800 * X_{56}; \end{aligned}$$

$$X_{50} + X_8 + X_9 + X_{10} + X_{11} + X_{12} + X_{13} > 1;$$

$$X_{51} + X_{14} + X_{15} + X_{16} + X_{17} + X_{18} + X_{19} > 1;$$

$$X_{52} + X_{20} + X_{21} + X_{22} + X_{23} + X_{24} + X_{25} > 1;$$

$$X_{53} + X_{26} + X_{27} + X_{28} + X_{29} + X_{30} + X_{31} > 1;$$

$$X_{54} + X_{32} + X_{33} + X_{34} + X_{35} + X_{36} + X_{37} > 1;$$

$$X_{55} + X_{38} + X_{39} + X_{40} + X_{41} + X_{42} + X_{43} > 1;$$

$$X_{56} + X_{44} + X_{45} + X_{46} + X_{47} + X_{48} + X_{49} > 1;$$

$$X_{50} + X_{51} + X_{52} + X_{53} + X_{54} + X_{55} + X_{56} = 2;$$

$$X_1 + X_{14} + X_{20} + X_{26} + X_{32} + X_{38} + X_{44} > 1;$$

$$X_2 + X_8 + X_{21} + X_{27} + X_{33} + X_{39} + X_{45} > 1;$$

$$X_3 + X_9 + X_{15} + X_{28} + X_{34} + X_{40} + X_{46} > 1;$$

$$X_4 + X_{10} + X_{16} + X_{22} + X_{35} + X_{41} + X_{47} > 1;$$

$$X_5 + X_{11} + X_{17} + X_{23} + X_{29} + X_{42} + X_{48} > 1;$$

$$X_6 + X_{12} + X_{18} + X_{24} + X_{30} + X_{36} + X_{49} > 1;$$

$$X_7 + X_{13} + X_{19} + X_{25} + X_{31} + X_{37} + X_{43} > 1;$$

$$X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7 = 2;$$

$$X_1 + X_{50} < 1;$$

$$X_2 + X_{51} < 1;$$

$$X_3 + X_{52} < 1;$$

$$X_4 + X_{53} < 1;$$

$$X5+X54<1;$$

$$X6+X55<1;$$

$$X7+X56<1;$$

$$X8+X14<1;$$

$$X9+X20<1;$$

$$X10+X26<1;$$

$$X11+X32<1;$$

$$X12+X38<1;$$

$$X13+X44<1;$$

$$X15+X21<1;$$

$$X16+X27<1;$$

$$X17+X33<1;$$

$$X18+X39<1;$$

$$X19+X46<1;$$

$$X22+X28<1;$$

$$X23+X34<1;$$

$$X24+X40<1;$$

$$X25+X46<1;$$

$$X29+X41<1;$$

$$X30+X41<1;$$

$$X31+X47<1;$$

$$X36+X42<1;$$

$$X37+X48<1;$$

$$X43+X49<1;$$

$$X1+X8+X51<2;$$

$$X1+X9+X52<2;$$

$$X1+X10+X53<2;$$

$$X1+X11+X54<2;$$

$$X1+X12+X55<2;$$

$$X1+X13+X56<2;$$

$$X2+X14+X50<2;$$

$$X2+X15+X52<2;$$

X2+X16+X53<2;
X2+X17+X54<2;
X2+X18+X55<2;
X2+X19+X56<2;
X3+X20+X50<2;
X3+X21+X51<2;
X3+X22+X53<2;
X3+X23+X54<2;
X3+X24+X55<2;
X3+X25+X56<2;
X4+X26+X50<2;
X4+X27+X51<2;
X4+X28+X52<2;
X4+X29+X54<2;
X4+X30+X55<2;
X4+X31+X56<2;
X4+X32+X50<2;
X5+X33+X51<2;
X5+X34+X52<2;
X5+X35+X53<2;
X5+X36+X55<2;
X5+X37+X56<2;
X6+X38+X50<2;
X6+X39+X51<2;
X6+X40+X52<2;
X6+X41+X53<2;
X6+X42+X54<2;
X6+X43+X56<2;
X7+X44+X50<2;
X7+X45+X51<2;
X7+X46+X52<2;
X7+X47+X53<2;
X7+X48+X54<2;

$$X7+X49+X55<2;$$

$$X8+X15+X20<2;$$

$$X8+X16+X26<2;$$

$$X8+X17+X32<2;$$

$$X8+X18+X38<2;$$

$$X8+X19+X44<2;$$

$$X9+X21+X14<2;$$

$$X9+X22+X26<2;$$

$$X9+X23+X32<2;$$

$$X9+X24+X38<2;$$

$$X9+X25+X44<2;$$

$$X10+X27+X14<2;$$

$$X10+X28+X20<2;$$

$$X10+X29+X32<2;$$

$$X10+X30+X38<2;$$

$$X10+X31+X44<2;$$

$$X11+X33+X14<2;$$

$$X11+X34+X20<2;$$

$$X11+X35+X26<2;$$

$$X11+X36+X38<2;$$

$$X11+X37+X44<2;$$

$$X12+X39+X14<2;$$

$$X12+X40+X20<2;$$

$$X12+X41+X26<2;$$

$$X12+X42+X32<2;$$

$$X12+X43+X44<2;$$

$$X13+X45+X14<2;$$

$$X13+X46+X20<2;$$

$$X13+X47+X26<2;$$

$$X13+X48+X32<2;$$

$$X13+X49+X38<2;$$

$$X14+X9+X21<2;$$

$$X14+X10+X27<2;$$

X14+X11+X33<2;
X14+X12+X39<2;
X14+X13+X45<2;
X15+X20+X8<2;
X15+X22+X27<2;
X15+X23+X33<2;
X15+X24+X39<2;
X15+X25+X45<2;
X16+X26+X8<2;
X16+X28+X21<2;
X16+X29+X33<2;
X16+X30+X39<2;
X16+X31+X45<2;
X17+X32+X8<2;
X17+X34+X21<2;
X17+X35+X27<2;
X17+X36+X39<2;
X17+X37+X45<2;
X18+X38+X8<2;
X18+X40+X21<2;
X18+X41+X27<2;
X18+X42+X33<2;
X18+X43+X45<2;
X19+X44+X8<2;
X19+X46+X21<2;
X19+X47+X27<2;
X19+X48+X33<2;
X19+X49+X39<2;
X20+X8+X15<2;
X20+X10+X28<2;
X20+X11+X34<2;
X20+X12+X40<2;
X20+X13+X46<2;

$$X21+X14+X9<2;$$

$$X21+X16+X28<2;$$

$$X21+X17+X34<2;$$

$$X21+X18+X40<2;$$

$$X21+X19+X46<2;$$

$$X22+X26+X9<2;$$

$$X22+X27+X15<2;$$

$$X22+X29+X34<2;$$

$$X22+X30+X40<2;$$

$$X22+X31+X46<2;$$

$$X23+X32+X9<2;$$

$$X23+X33+X15<2;$$

$$X23+X35+X28<2;$$

$$X23+X36+X40<2;$$

$$X23+X37+X46<2;$$

$$X24+X38+X9<2;$$

$$X24+X39+X15<2;$$

$$X24+X41+X28<2;$$

$$X24+X42+X34<2;$$

$$X24+X43+X46<2;$$

$$X25+X44+X9<2;$$

$$X25+X45+X15<2;$$

$$X25+X47+X28<2;$$

$$X25+X48+X34<2;$$

$$X25+X49+X40<2;$$

$$X26+X8+X16<2;$$

$$X26+X9+X22<2;$$

$$X26+X11+X35<2;$$

$$X26+X12+X41<2;$$

$$X26+X13+X47<2;$$

$$X27+X14+X10<2;$$

$$X27+X15+X22<2;$$

$$X27+X17+X35<2;$$

X27+X18+X41<2;
X27+X19+X47<2;
X28+X20+X10<2;
X28+X21+X16<2;
X28+X23+X35<2;
X28+X24+X41<2;
X28+X25+X47<2;
X29+X32+X10<2;
X29+X33+X16<2;
X29+X34+X22<2;
X29+X36+X41<2;
X29+X37+X47<2;
X30+X38+X10<2;
X30+X39+X16<2;
X30+X40+X22<2;
X30+X42+X35<2;
X30+X43+X47<2;
X31+X44+X10<2;
X31+X45+X16<2;
X31+X46+X22<2;
X31+X48+X35<2;
X31+X49+X41<2;
X32+X8+X17<2;
X32+X9+X23<2;
X32+X10+X29<2;
X32+X12+X42<2;
X32+X13+X48<2;
X33+X14+X11<2;
X33+X15+X23<2;
X33+X16+X29<2;
X33+X18+X42<2;
X33+X19+X48<2;
X34+X20+X11<2;

X34+X21+X17<2;
X34+X22+X29<2;
X34+X24+X42<2;
X34+X25+X48<2;
X35+X26+X11<2;
X35+X27+X17<2;
X35+X28+X23<2;
X35+X30+X42<2;
X35+X31+X48<2;
X36+X38+X11<2;
X36+X39+X17<2;
X36+X40+X23<2;
X36+X41+X29<2;
X36+X43+X48<2;
X37+X44+X11<2;
X37+X45+X17<2;
X37+X46+X23<2;
X37+X47+X29<2;
X37+X49+X42<2;
X38+X8+X18<2;
X38+X9+X24<2;
X38+X10+X30<2;
X38+X11+X36<2;
X38+X13+X49<2;
X39+X14+X12<2;
X39+X15+X24<2;

N1>1;

N2>1;

N3>1;

N4>1;

N5>2;

N6>1;

$N7 > 1;$

$N1 + N2 + N3 + N4 + N5 + N6 + N7 > 1;$

@GIN(N1);

@GIN(N2);

@GIN(N3);

@GIN(N4);

@GIN(N5);

@GIN(N6);

@GIN(N7);

@BIN(X1);

@BIN(X2);

@BIN(X3);

@BIN(X4);

@BIN(X5);

@BIN(X6);

@BIN(X7);

@BIN(X8);

@BIN(X9);

@BIN(X10);

@BIN(X11);

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@BIN(X14);

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@BIN(X17);

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@BIN(X19);

@BIN(X20);

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@BIN(X24);
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@BIN(X26);
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@BIN(X28);
@BIN(X29);
@BIN(X30);
@BIN(X31);
@BIN(X32);
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@BIN(X40);
@BIN(X41);
@BIN(X42);
@BIN(X43);
@BIN(X44);
@BIN(X45);
@BIN(X46);
@BIN(X47);
@BIN(X48);
@BIN(X49);
@BIN(X50);
@BIN(X51);
@BIN(X52);
@BIN(X53);
@BIN(X54);
@BIN(X55);
@BIN(X56); END

Solución obtenida por LINGO

Local optimal solution found at step: 45
Objective value: 2637.000
Branch count: 0

Variable	Value	Reduced Cost
X1	0.000000	0.000000
N1	1.000000	0.000000
X2	1.000000	0.000000
N2	1.000000	0.000000
X3	0.000000	0.000000
N3	1.000000	0.000000
X4	0.000000	0.000000
N4	1.000000	2.000000
X5	0.000000	2.000000
N5	2.000000	0.000000
X6	0.000000	0.000000
N6	1.000000	0.000000
X7	1.000000	0.000000
N7	1.000000	0.000000
X8	0.000000	0.000000
X9	0.000000	0.000000
X10	1.000000	0.000000
X11	0.000000	0.000000
X12	0.000000	0.000000
X13	0.000000	2.000000
X14	1.000000	0.000000
X15	0.000000	0.000000
X16	0.000000	0.000000
X17	0.000000	0.000000
X18	0.000000	0.000000
X19	0.000000	0.000000

X20	0.000000	0.000000
X21	0.000000	2.000000
X22	0.000000	0.000000
X23	0.000000	0.000000
X24	0.000000	0.000000
X25	0.000000	0.000000
X26	0.000000	0.000000
X27	0.000000	0.000000
X28	1.000000	0.000000
X29	0.000000	2.000000
X30	0.000000	0.000000
X31	0.000000	0.000000
X32	0.000000	0.000000
X33	0.000000	0.000000
X34	0.000000	0.000000
X35	0.000000	0.000000
X36	0.000000	0.000000
X37	0.000000	2.000000
X38	0.000000	0.000000
X39	0.000000	0.000000
X40	0.000000	0.000000
X41	0.000000	0.000000
X42	1.000000	0.000000
X43	0.000000	0.000000
X44	0.000000	0.000000
X45	0.000000	2.000000
X46	0.000000	0.000000
X47	0.000000	0.000000
X48	0.000000	0.000000
X49	1.000000	0.000000
X50	0.000000	0.000000
X51	0.000000	0.000000
X52	1.000000	0.000000

X53	0.0000000	2.0000000
X54	1.0000000	0.0000000
X55	0.0000000	0.0000000
X56	0.0000000	0.0000000

Nota:

La ruta del segundo turno será igual que la del primero eliminando el nodo T1.

Ruta para el 3er. Turno

$$\begin{aligned} \text{MIN} = & 520 * X1 * N1 + 521 * X2 * N2 + 450 * X5 * N5 + 565 * X6 * N6 + X8 * N2 + 418 * X11 * N5 + 533 * X12 * N6 + \\ & X14 * N1 + 419 * X17 * N5 + 534 * X18 * N6 + 418 * X32 * N1 + 419 * X33 * N2 + 115 * X36 * N6 + 533 * X38 * N1 + \\ & 534 * X39 * N2 + 115 * X42 * N5 + 520 * X50 + 521 * X51 + 450 * X54 + 565 * X55; \end{aligned}$$

$$X50 + X8 + X11 + X12 = 1;$$

$$X51 + X14 + X17 + X18 = 1;$$

$$X54 + X32 + X33 + X36 = 1;$$

$$X55 + X38 + X39 + X42 = 1;$$

$$X50 + X51 + X54 + X55 > 1;$$

$$X1 + X14 + X32 + X38 = 1;$$

$$X2 + X8 + X33 + X39 = 1;$$

$$X5 + X11 + X17 + X42 = 1;$$

$$X6 + X12 + X18 + X36 = 1;$$

$$X1 + X2 + X5 + X6 > 1;$$

$$X1 + X50 < 1;$$

$$X2 + X51 < 1;$$

$$X5 + X54 < 1;$$

$$X6 + X55 < 1;$$

$$X8 + X14 < 1;$$

$$X11 + X32 < 1;$$

$$X12 + X38 < 1;$$

$$X17 + X33 < 1;$$

$$X18 + X39 < 1;$$

$$X36 + X42 < 1;$$

$$X1 + X8 + X51 < 2;$$

$$X1 + X11 + X54 < 2;$$

$$X1 + X12 + X55 < 2;$$

$$X2 + X14 + X50 < 2;$$

$$X2+X17+X54<2;$$

$$X2+X18+X55<2;$$

$$X5+X33+X51<2;$$

$$X5+X36+X55<2;$$

$$X6+X38+X50<2;$$

$$X6+X39+X51<2;$$

$$X6+X42+X54<2;$$

$$X8+X17+X32<2;$$

$$X8+X18+X38<2;$$

$$X11+X33+X14<2;$$

$$X11+X34+X20<2;$$

$$X11+X35+X26<2;$$

$$X11+X36+X38<2;$$

$$X12+X39+X14<2;$$

$$X12+X40+X20<2;$$

$$X12+X41+X26<2;$$

$$X12+X42+X32<2;$$

$$X14+X9+X21<2;$$

$$X14+X11+X33<2;$$

$$X14+X12+X39<2;$$

$$X17+X32+X8<2;$$

$$X17+X34+X21<2;$$

$$X17+X35+X27<2;$$

$$X17+X36+X39<2;$$

$$X18+X38+X8<2;$$

$$X18+X40+X21<2;$$

$$X18+X41+X27<2;$$

$$X18+X42+X33<2;$$

$$X32+X8+X17<2;$$

$$X32+X12+X42<2;$$

$$X33+X14+X11<2;$$

$$X33+X18+X42<2;$$

$$X36+X38+X11<2;$$

$X36+X39+X17<2;$ $X38+X8+X18<2;$ $X38+X11+X36<2;$ $X38+X8+X18<2;$ $X38+X11+X36<2;$ $X39+X14+X12<2;$ $X39+X17+X36<2;$ $X42+X32+X12<2;$ $X42+X33+X18<2;$ $N1>1;$ $N2>1;$ $N5>2;$ $N6>1;$ $N1+N2+N5+N6>1;$ $@GIN(N1);$ $@GIN(N2);$ $@GIN(N5);$ $@GIN(N6);$ $@BIN(X1);$ $@BIN(X2);$ $@BIN(X5);$ $@BIN(X6);$ $@BIN(X8);$ $@BIN(X11);$ $@BIN(X12);$ $@BIN(X14);$ $@BIN(X17);$ $@BIN(X18);$ $@BIN(X32);$ $@BIN(X33);$

@BIN(X36);

@BIN(X38);

@BIN(X39);

@BIN(X42);

@BIN(X50);

@BIN(X51);

@BIN(X54);

@BIN(X55);

END

Solución obtenida por LINGO

Local optimal solution found at step: 2258
Objective value: 1735.000
Branch count: 0

Variable	Value	Reduced Cost
X1	0.000000	0.000000
N1	1.000000	0.000000
X2	0.000000	0.000000
N2	1.000000	0.000000
X5	0.000000	0.000000
N5	2.000000	0.000000
X6	1.000000	0.000000
N6	1.000000	0.000000
X8	1.000000	0.000000
X11	0.000000	0.000000
X12	0.000000	0.000000
X14	0.000000	0.000000
X17	0.000000	0.000000
X18	0.000000	0.000000
X32	1.000000	0.000000
X33	0.000000	0.000000
X36	0.000000	0.000000
X38	0.000000	0.000000
X39	0.000000	0.000000
X42	1.000000	0.000000
X50	0.000000	0.000000
X51	1.000000	0.000000
X54	0.000000	0.000000
X55	0.000000	0.000000
X34	0.000000	0.000000
X20	0.000000	0.000000

X35	0.0000000	0.0000000
X26	0.0000000	0.0000000
X40	0.0000000	0.0000000
X41	0.0000000	0.0000000
X9	0.0000000	0.0000000
X21	0.0000000	0.0000000
X27	0.0000000	0.0000000