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Modelling the risk & availability of elevator devices to users in Toronto, New York City & Mumbai

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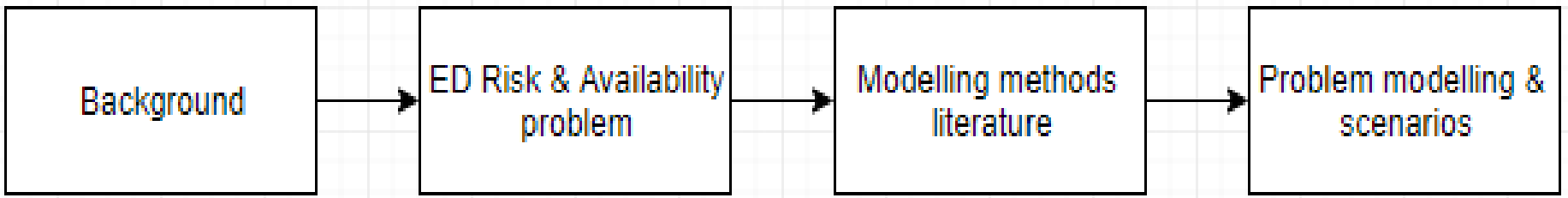
Agenda



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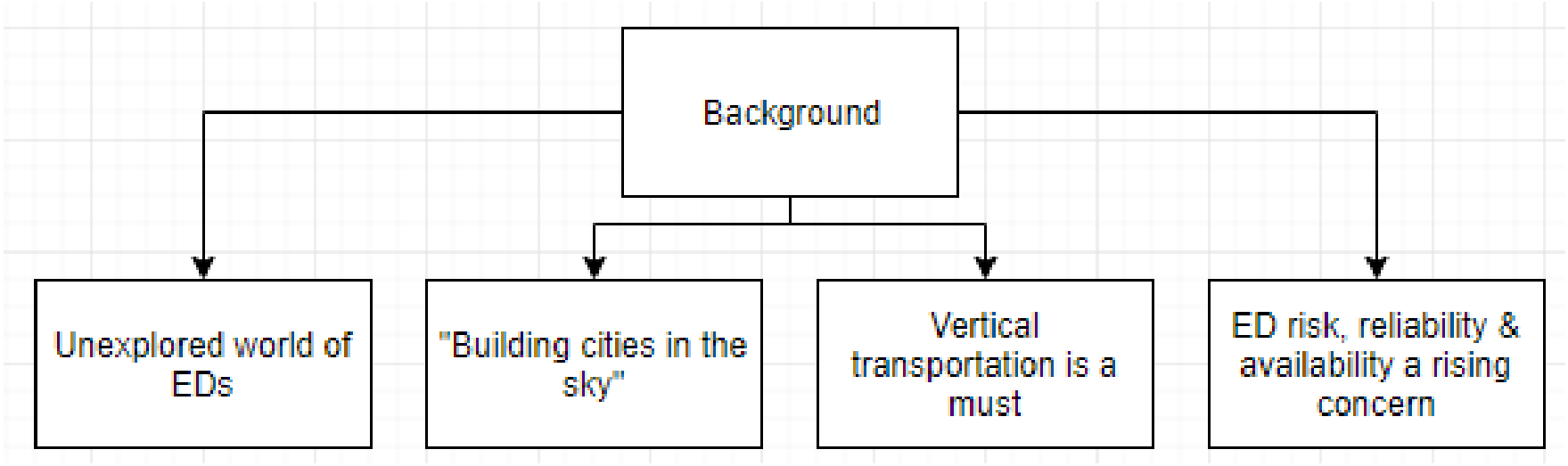
Context



Comparison of ED population at risk

Existing passenger elevators	66,602
Existing freight elevators	4,140
Existing escalators	2,663
Existing dumbwaiters	1,143
Existing sidewalk elevators	943
Existing private elevators	252
Existing handicap elevators	227
Existing manlifts	73
Existing public elevators	45

Ontario (2016)

Existing passenger elevators	41,677
Existing freight elevators	2,696
Existing escalators	2,071
Existing moving walks	43
Existing dumbwaiters	1,153

NY (2015)

Existing elevators	440,000
Existing escalators & moving walks	12,500

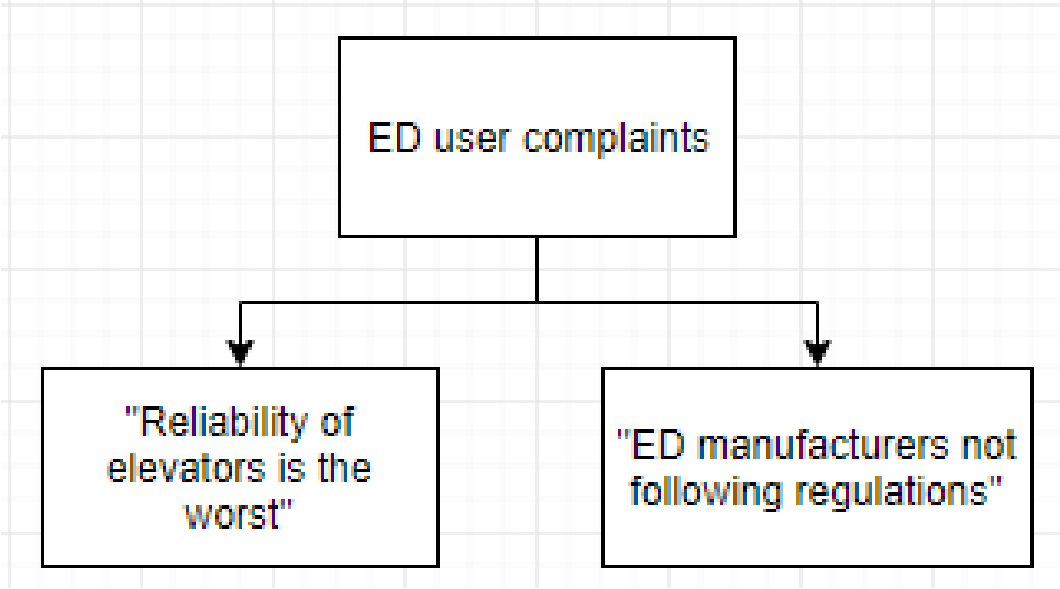
India (2016)

Building Purpose	Toronto	NYC	Mumbai
Residential (%)	82	52	85
Office (%)	15	39	12
Hotel & Other (%)	3	9	3

Comparing building purpose (2017)

Ontario ED user concerns

- First to setup ED repair timelines
- Several user concerns



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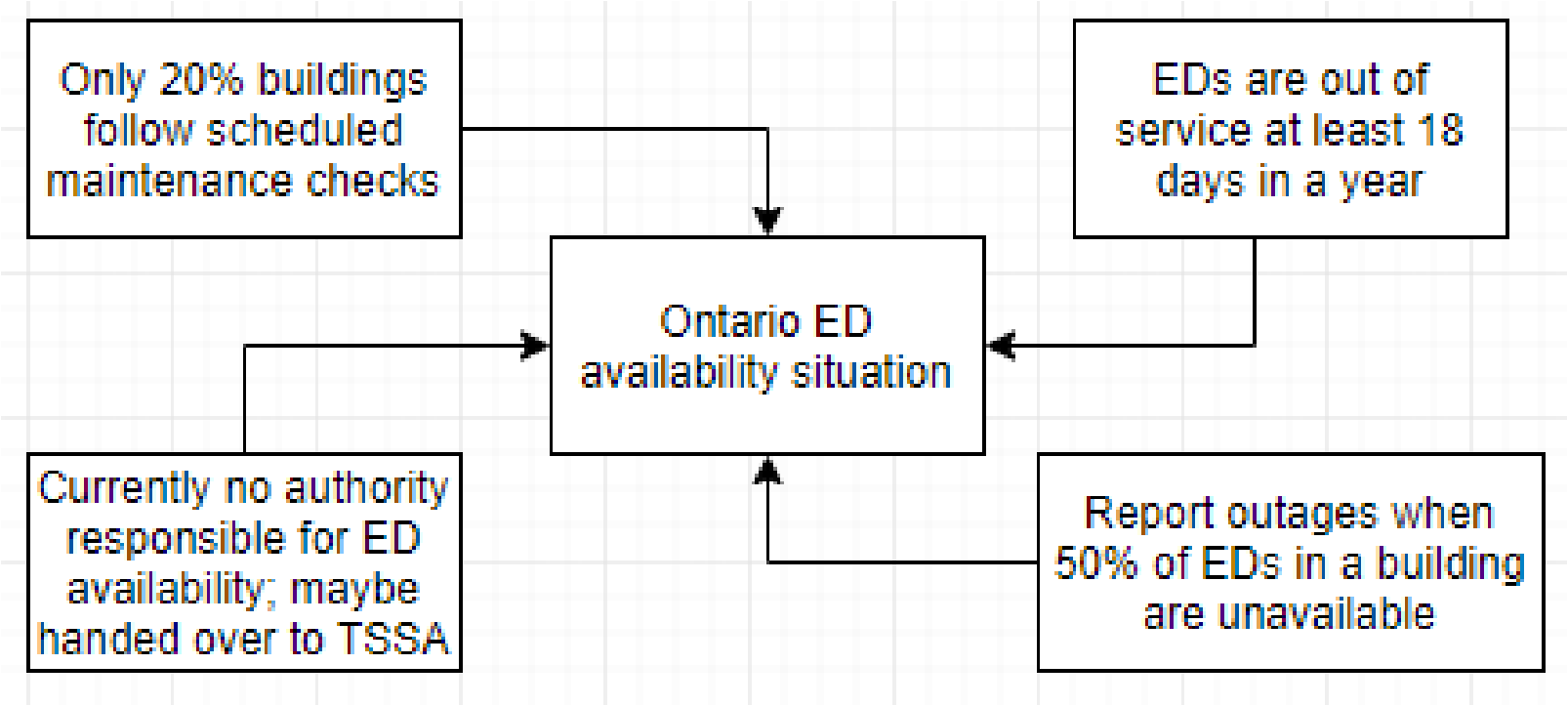
Ontario EDs availability



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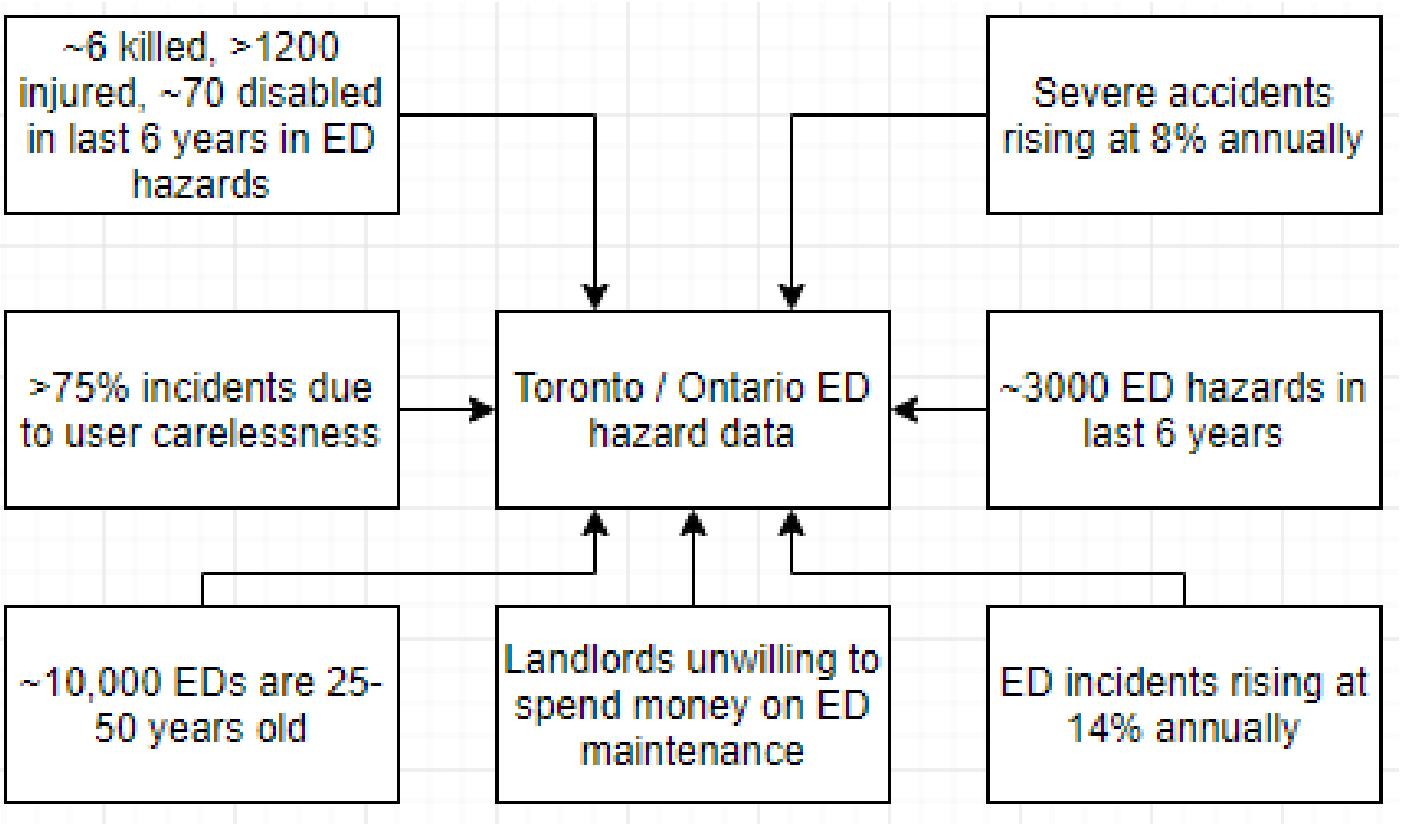
Ontario EDs hazard stats



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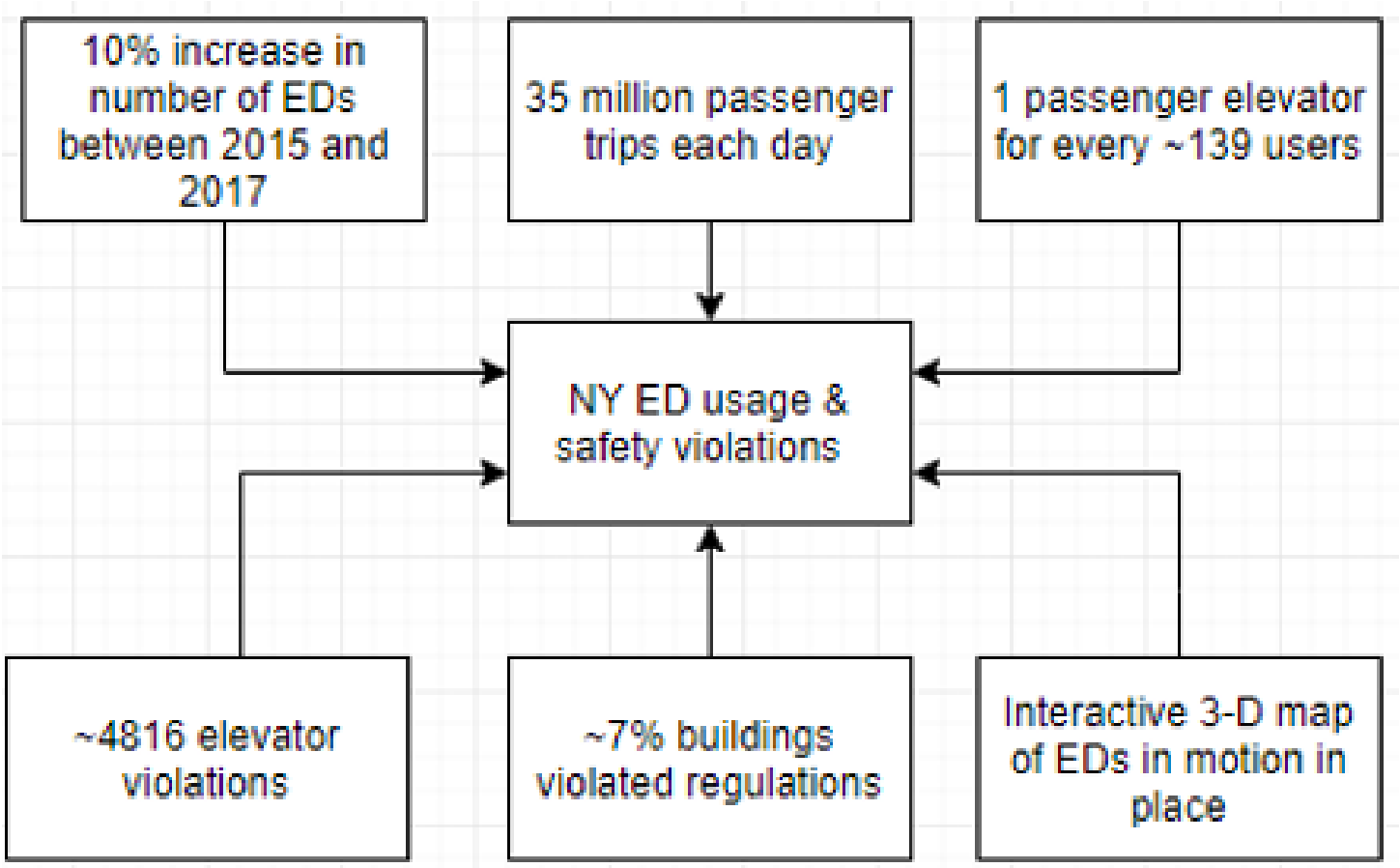
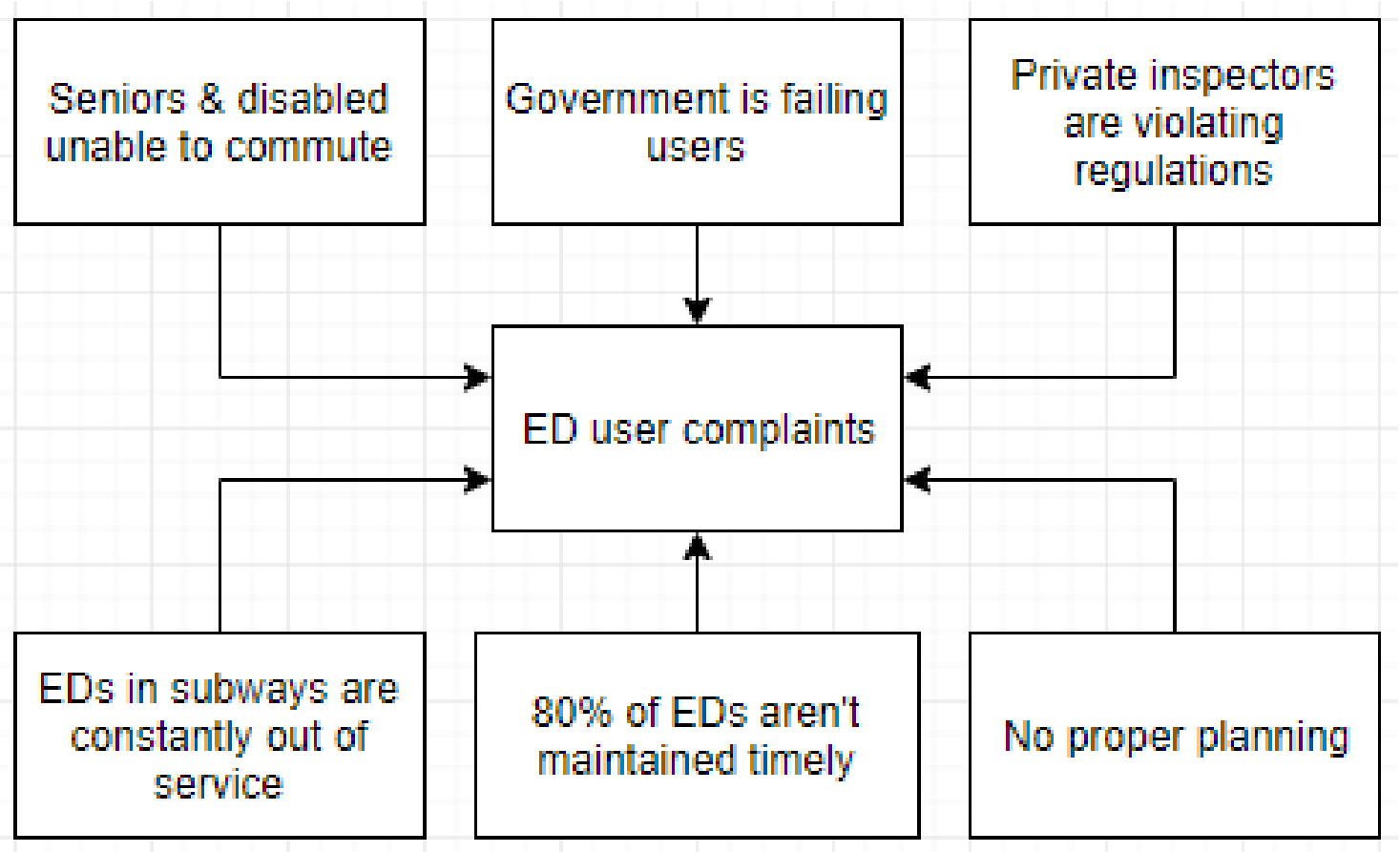
New York EDs usage & violations



New York EDs user concerns



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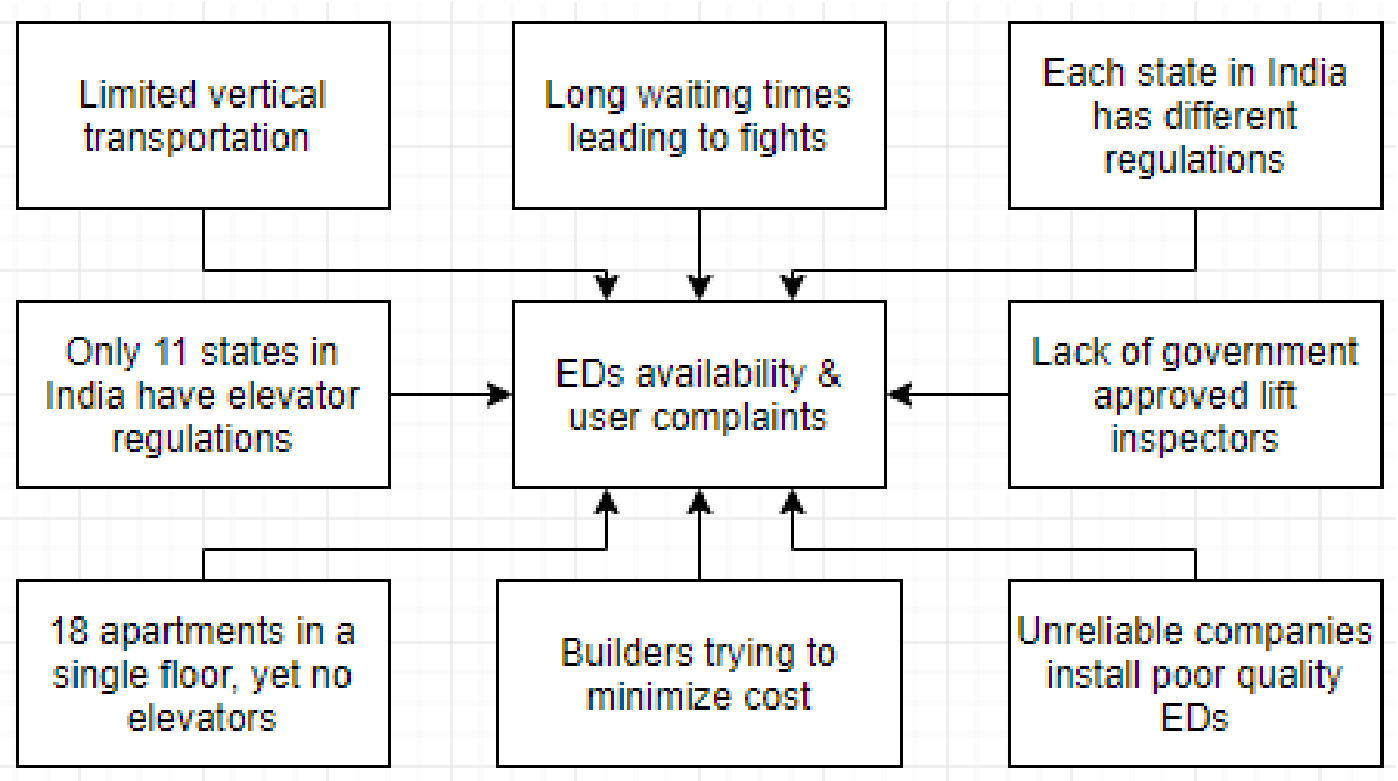
Mumbai EDs availability & user concerns



Ontario ED regulatory framework (1/3)

Organization name	Technical Standards and Safety Authority (TSSA)
Region served	Territory of Ontario
CEO / President	Bonnie Rose
ED safety Act / Bill	Technical Standards & Safety Act, 2000
Founded	1997
Organization type	Self-funded / Not-for-profit
Head office	Toronto
Total employees	~400
Elevator code	ASME A17.1-2010 / CSA B44.10
Purpose & Areas of service	Ensure public safety in EDs, Ski Lifts, Amusement Devices, Stuffed Articles, Fuels, Boilers, Pressure Vessels

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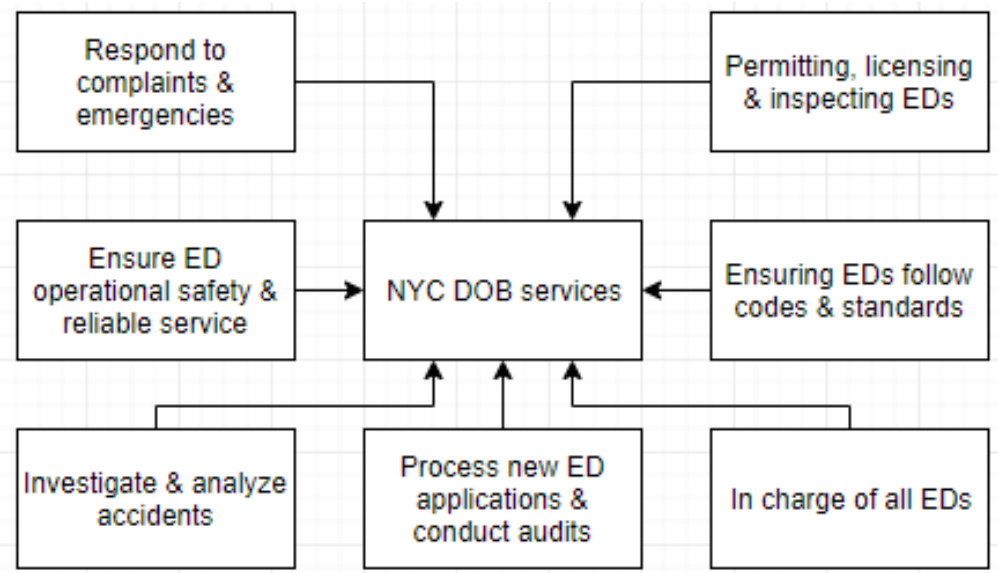
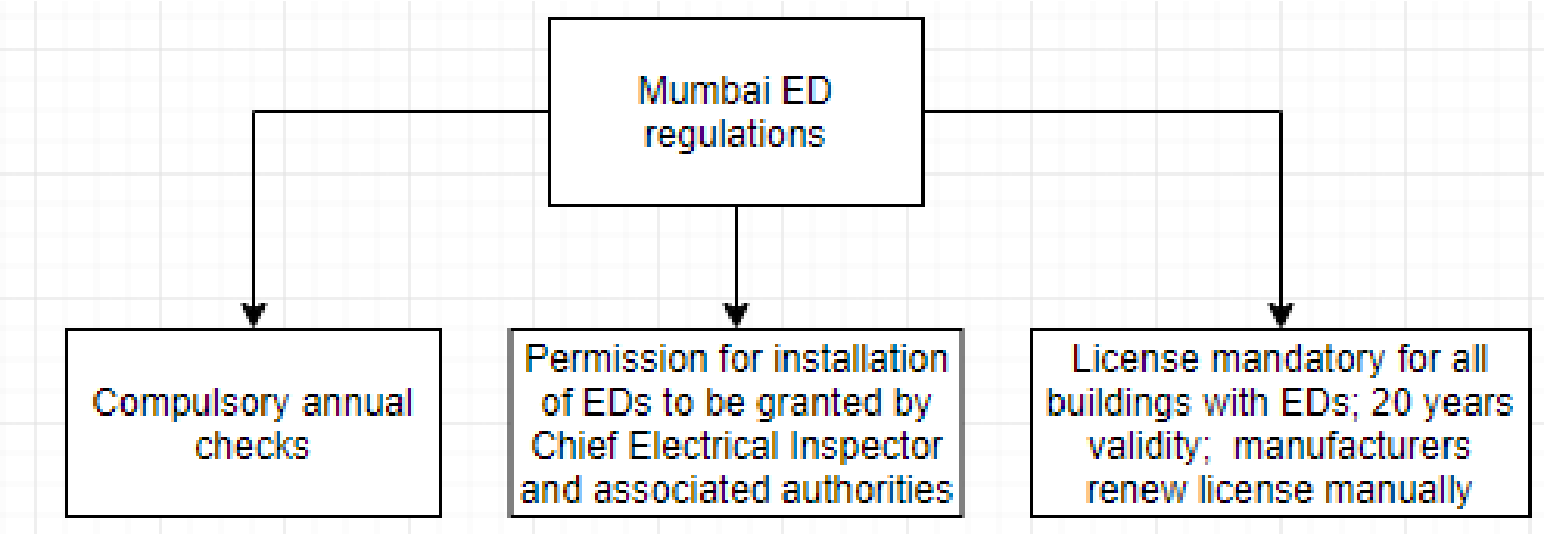
New York ED regulatory framework

Organization name	New York City Department of Buildings
Region served	State of New York
Commissioner	Rick Chandler
Founded	1977
Total employees	~1200
Head office	New York City
Elevator code	ASME A17.1-2005
Purpose	Ensure safety of all people that build, work & live in New York



Mumbai ED regulatory framework

Organization name	Lift Inspection Division, Maharashtra State Energy Department
Lift Act	Maharashtra Lifts, Escalators, Moving Walks Act, 2017
Law applicable	State of Maharashtra
Previous Lift Act	Maharashtra Lift Act, 1939
Standard	BIS 14665



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Region-wise ED & building regulations (1/2)

Matter	Toronto	NYC	Mumbai
Authority for enforcing building requirements	Ministry of Municipal Affairs	NYC DOB	Government of Maharashtra
Min requirement for elevator in buildings	Seven stories or more	Five stories or more	Not Available
Authority for enforcing fire requirements	Ministry of Municipal Affairs	NYC DOB	Government of Maharashtra, Electrical Inspector (Lifts)
ED requirements in case of fire	Residential buildings more than 18m high need at least one firefighter elevator and at least one in the case of care homes	Buildings with five or more floors, one elevator for Fire Department personnel to access all floors	Not Available
Authority for ED safety, availability	TSSA, Ontario (Provincial)	Elevator Unit, NYC DOB	Electrical Inspector (Lift Inspection Division), Maharashtra State Energy Dept., BIS
National regulation & standard for elevator safety	NBC of Canada, A17.1 / CSA B44	ASME A17.1 safety code for elevators & escalators	NBC, BIS
State / Provincial regulation for building & elevator safety	Ontario Building Code, Ontario Fire Code, Building Code Act	New York State Building Code, Elevator Code	Government of Maharashtra, National Building Code, BIS

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Region-wise ED & building regulations (2/2)

Matter	Toronto	NYC	Mumbai
Responsibility of making sure maintenance and repair of EDs happen	Building owner and elevator contractor having license from TSSA	Building owner	Government approved contractor possessing license from Chief Electrical Inspector
Safety precautions for members of public & compensation for injured or inconvenienced	Primarily keep building occupants informed well in advance of faulty elevators; no information on compensation in case of injuries	Keep building occupants informed; no information on compensation in case of injuries	Through third party insurance
Municipal regulation for building & elevator safety	Ontario Fire Code, Building Code Act, Ontario Building Code	NYC Building Code, Elevator Code	Government of Maharashtra, National Building Code, BIS
Minimum time for repairing faulty ED	7 days for long-term care homes; 14 days for all other buildings	Based on approval of report submitted to Elevator Area Chief; If approved, time is approved as mentioned in the report; otherwise 45 business days plus 15 business days to certify correction	No time constraints; as decided by lift owner, his representative or contractor

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ED risk modelling – Literature (1/2)

Model	Combination of PN, Bow-tie & FTA models (Vileiniskis, M & Remenyte-Prescott, R, 2016)
Purpose	Develop elevator risk & reliability framework
Methodology	Constructed based on elevator's operating condition, component degradation, operation & maintenance; probabilistic outputs of PN fed as inputs into Bow-Tie to calculate risk estimates of top event; then perform Monte Carlo simulation to predict performance & failure of elevator components; these failures are modeled using FTA and Boolean Logic

Model	FTA for elevator risk & availability modelling (TSSA, 2017)
Purpose	Determine elevator non-availability
Methodology	Determined in terms of hazards to passengers and measured in terms of probability of a fatal accident per year; then compared with a risk acceptability criteria of a probability of 1 out of xx fatalities per year

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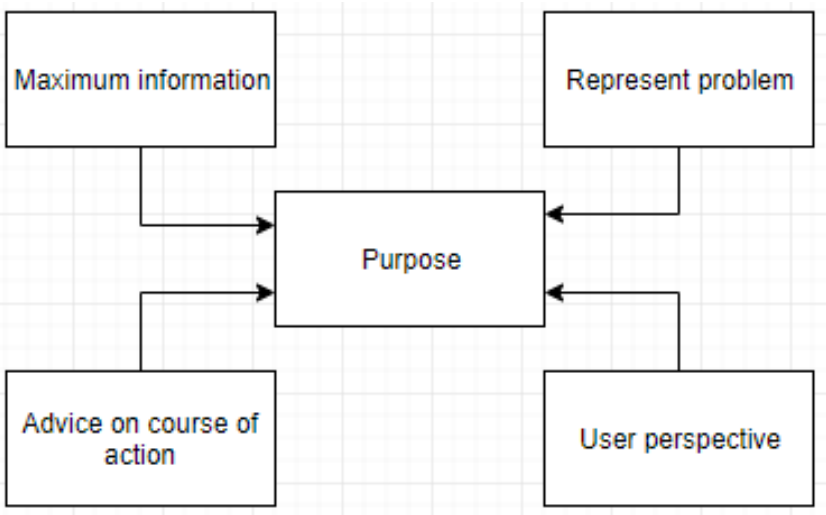
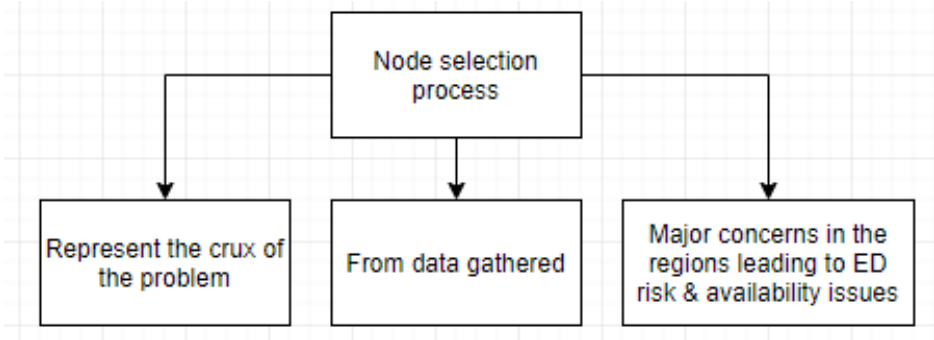
ED risk modelling – Literature (2/2)

Model	Multi-State Fuzzy Bayesian Network (Zhang, R. et al., 2014)
Purpose	To determine exact value of fault probability of elevator components by extending Bayesian Nets with Fuzzy Theory
Methodology	A Bayesian Net model of the elevator's horizontal vibration was built based on the logical relationship between factors; importance degree of factors affecting elevator's horizontal vibration is retrieved by importance analysis; elevator is maintained and checked using this importance degree; three state space {0,1,2} was used to represent various states of elevator components

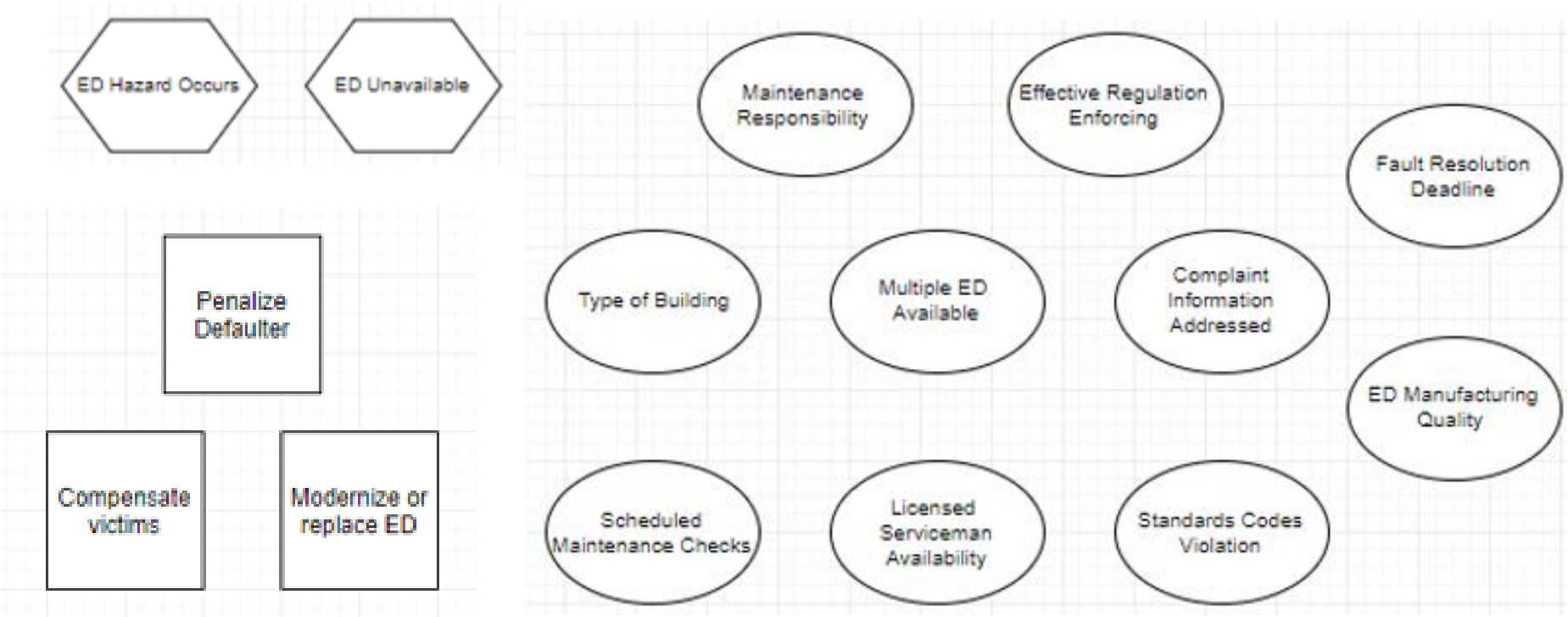
Model	Risk estimation using ALARP model (Rogova, E., 2017)
Purpose	To label different levels of elevator risk and to quantitatively define the class of risk
Methodology	Safety Integrity Level (SIL) of the braking system of a moving walk was analyzed; accidents happening in moving walks were classified into four consequence levels; this way the relationship between brakes unavailability and resulting consequences was studied;

ID model for ED risk & availability (1/8)





ID model for ED risk & availability (2/8)



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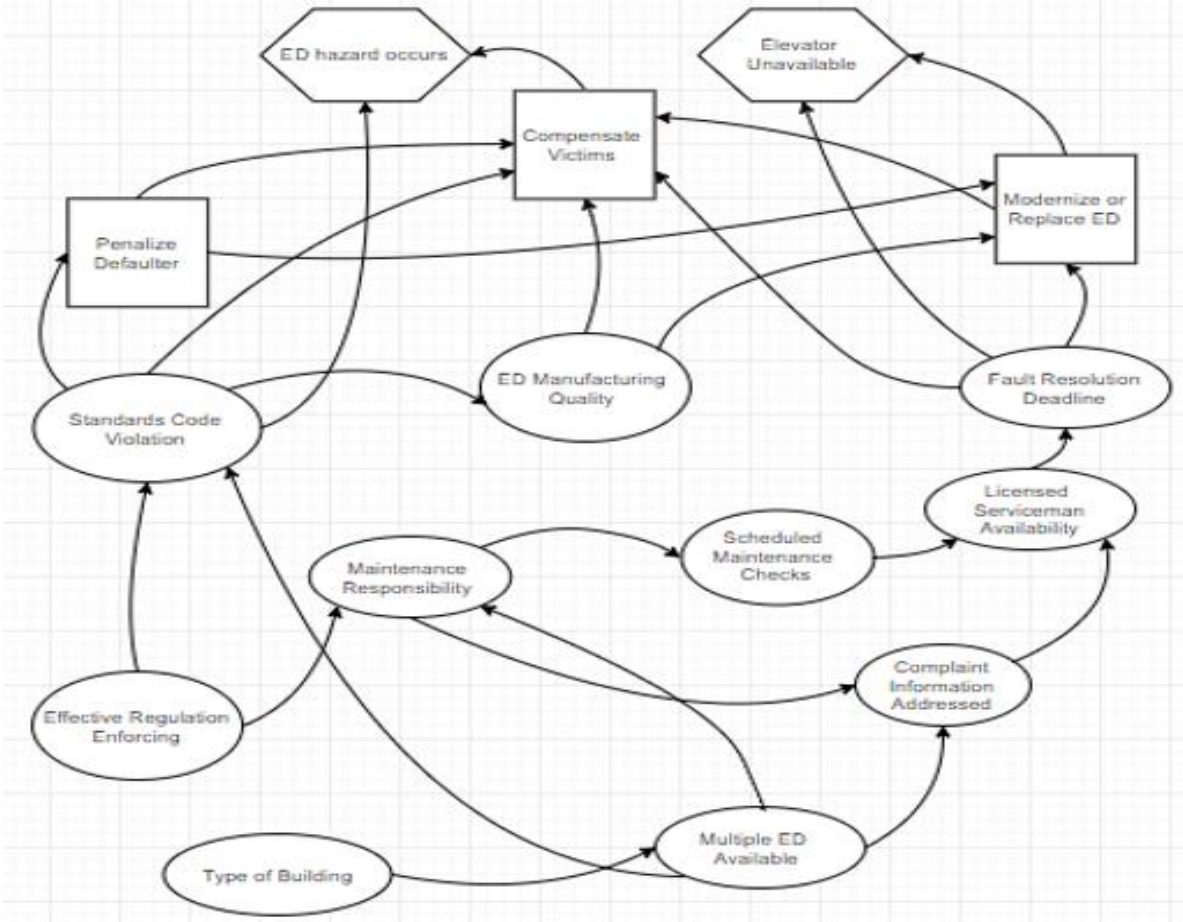
ID model for ED risk & availability (3/8)



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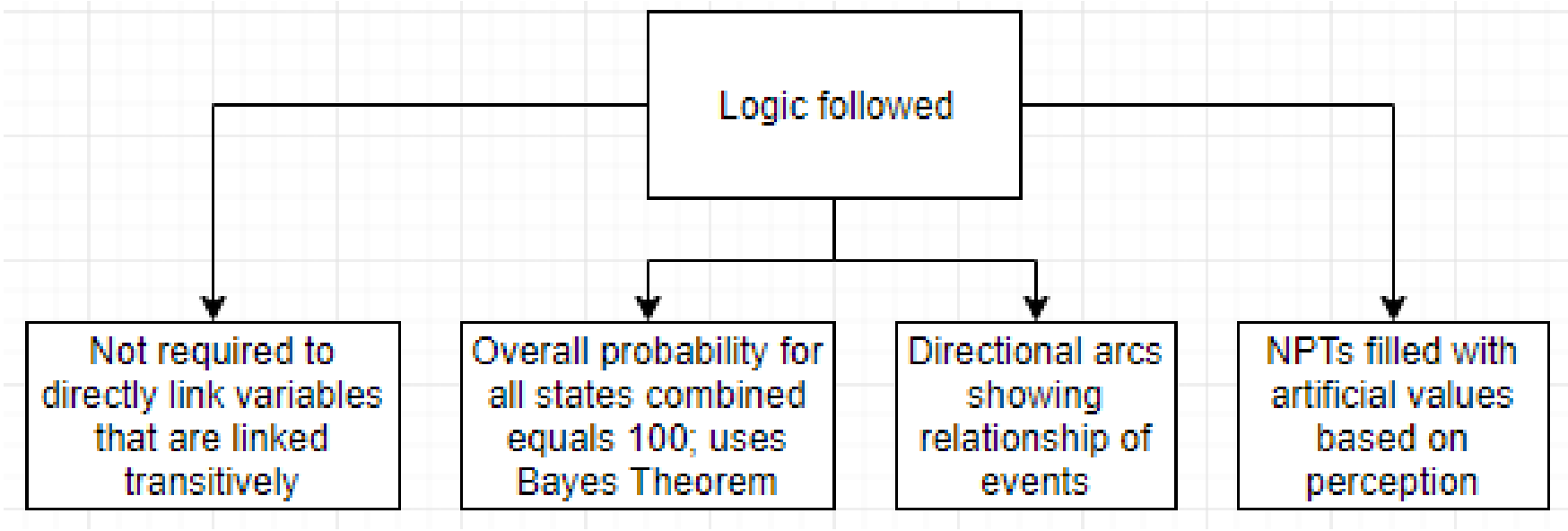
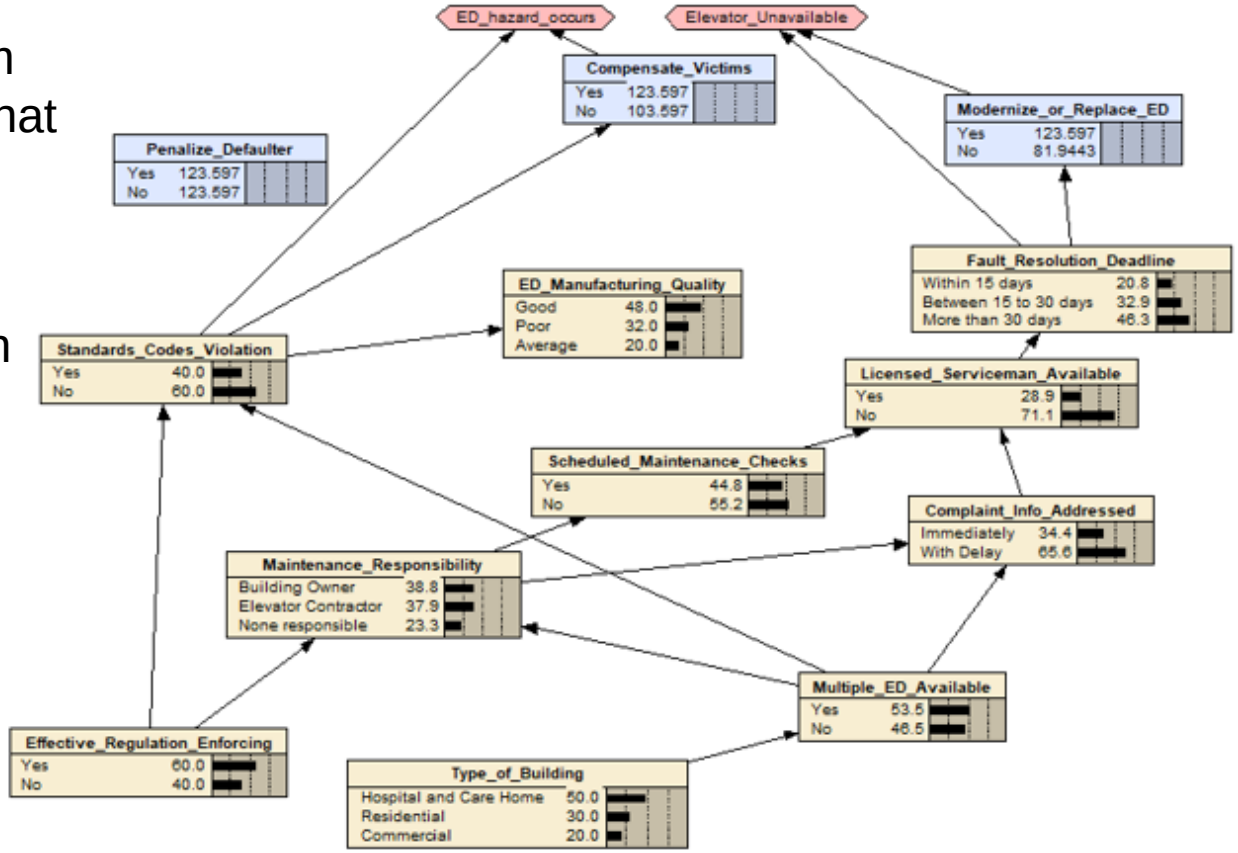
ID model for ED risk & availability (4/8)

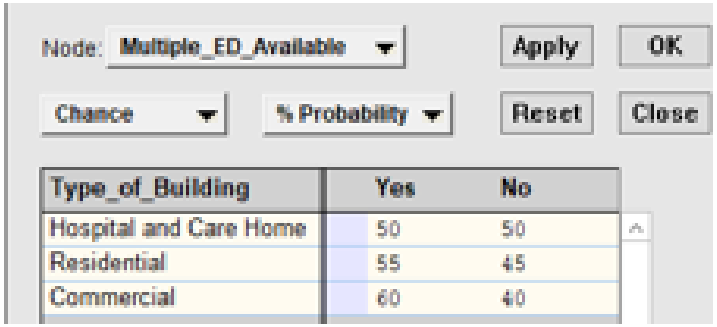


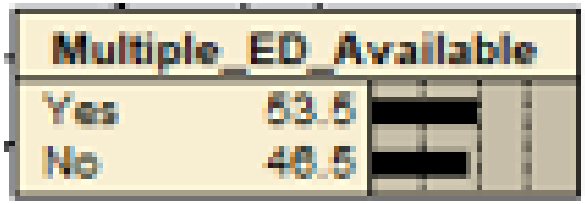
ID model for ED risk & availability (5/8)

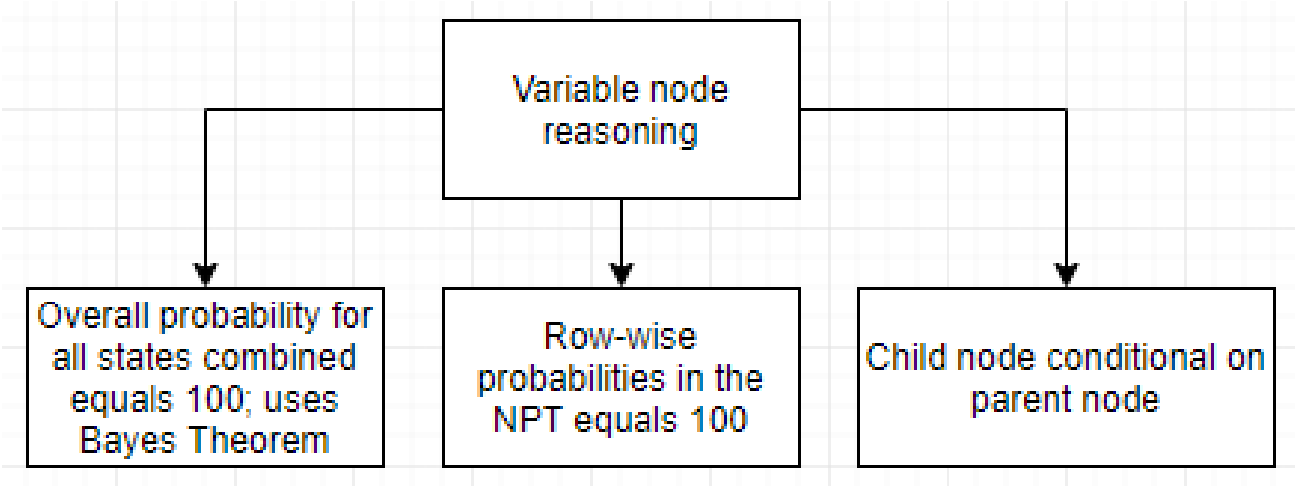
Removal of links to / from decision nodes means, that link is not relevant to the decision for all possible NPTs – performed by Netica during compilation



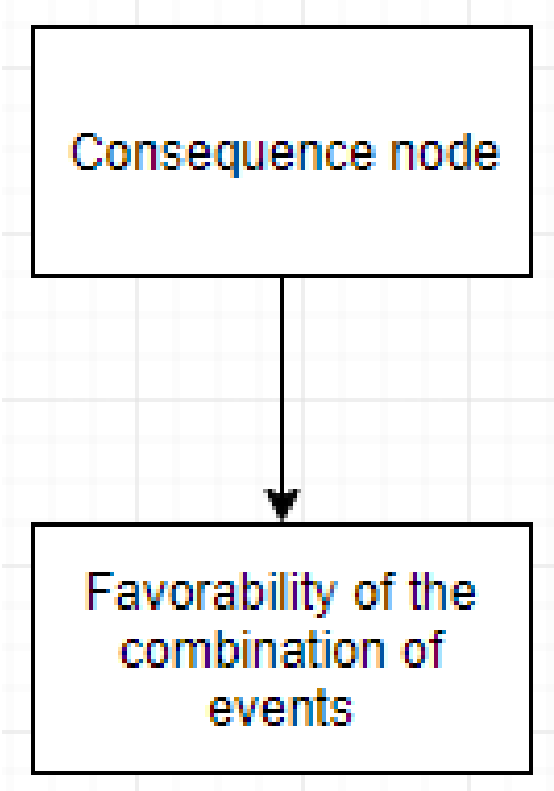
ID model for ED risk & availability (6/8)







ID model for ED risk & availability (7/8)



Node: ED_hazard_occurs

Apply | OK | Reset | Close

Deterministic | Function

Compensate_Victims	Standards_and_Codes_violation	ED_hazard_occurs
Yes	Yes	100
Yes	No	20
No	Yes	80
No	No	0

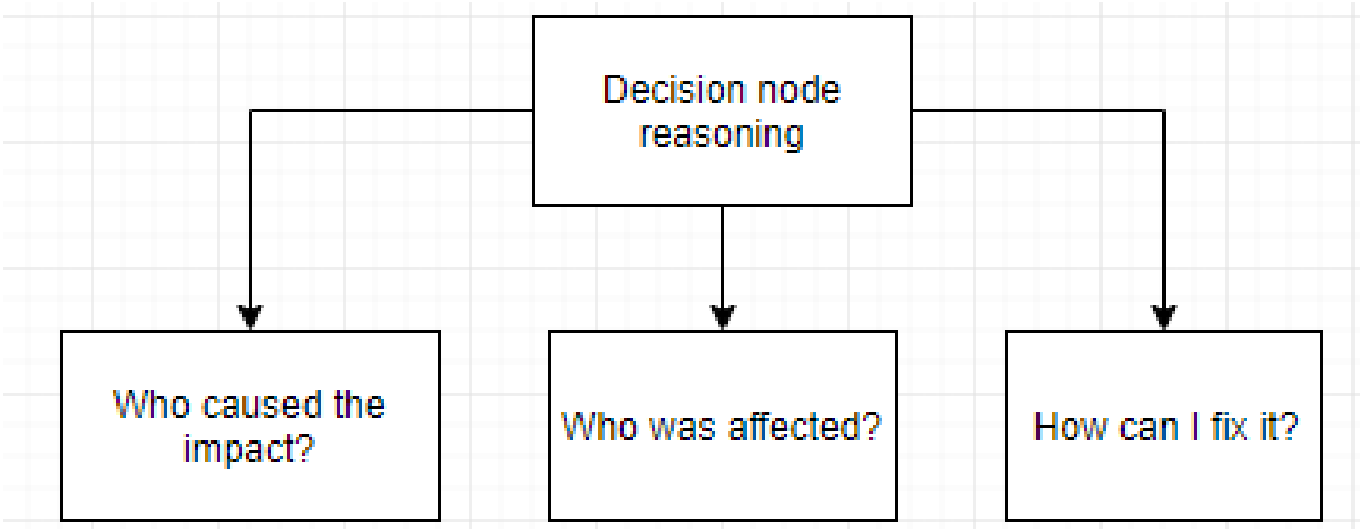
ID model for ED risk & availability (8/8)

Compensate_Victims	
Yes	123.597
No	103.597

Penalize_Defaulter	
Yes	123.597
No	123.597

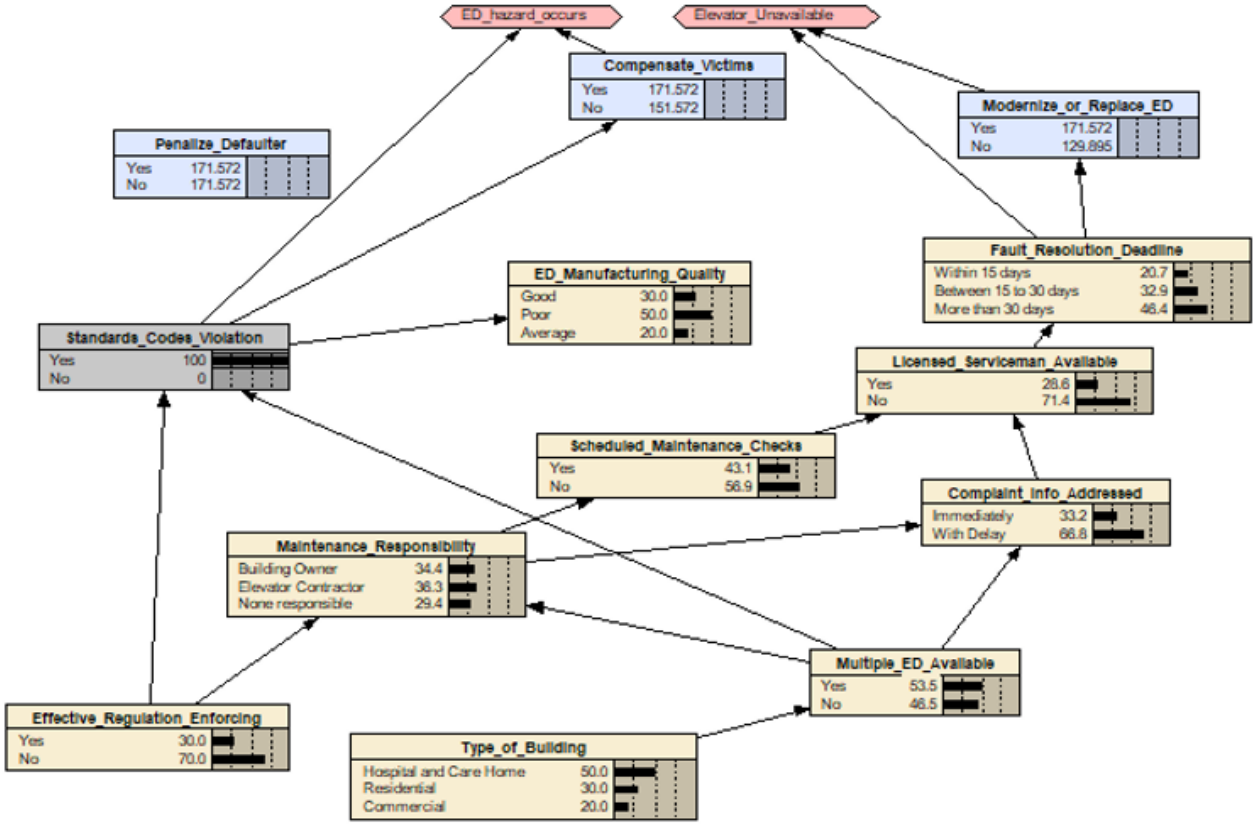
Modernize_or_Replace_ED	
Yes	123.597
No	81.9443

Output by Netica; opt for state with higher utility (not % values)



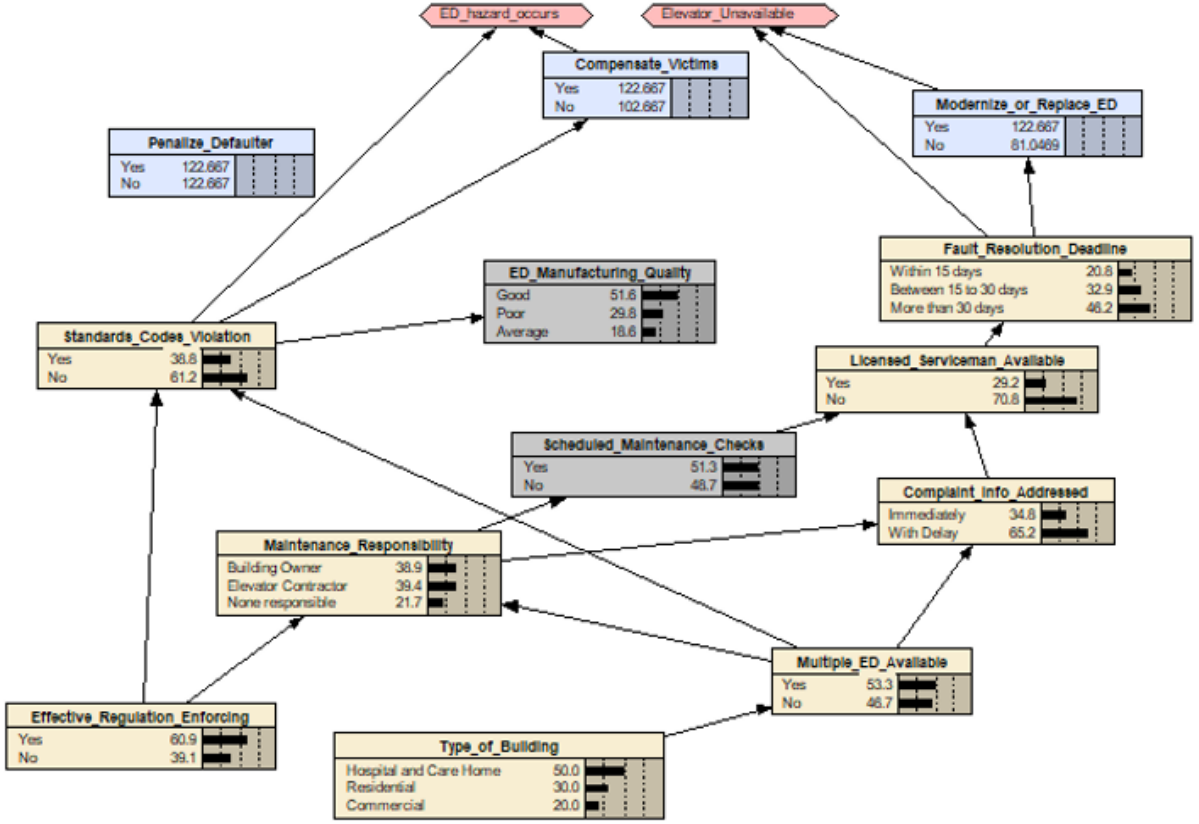
Scenarios and implications demo (1/4)

- Selecting a state



Scenarios and implications demo (2/4)

- Drag black bar



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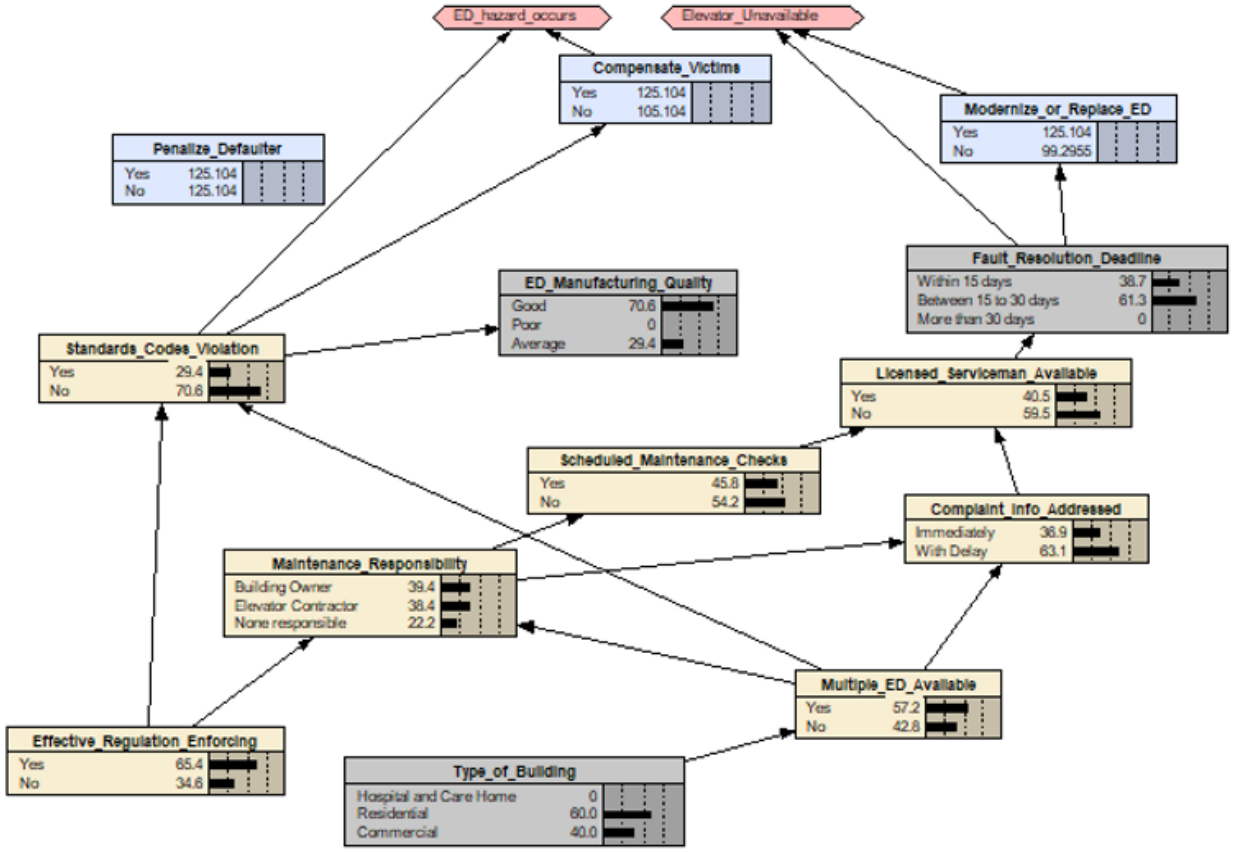
Scenarios and implications demo (3/4)

- Deselect a state



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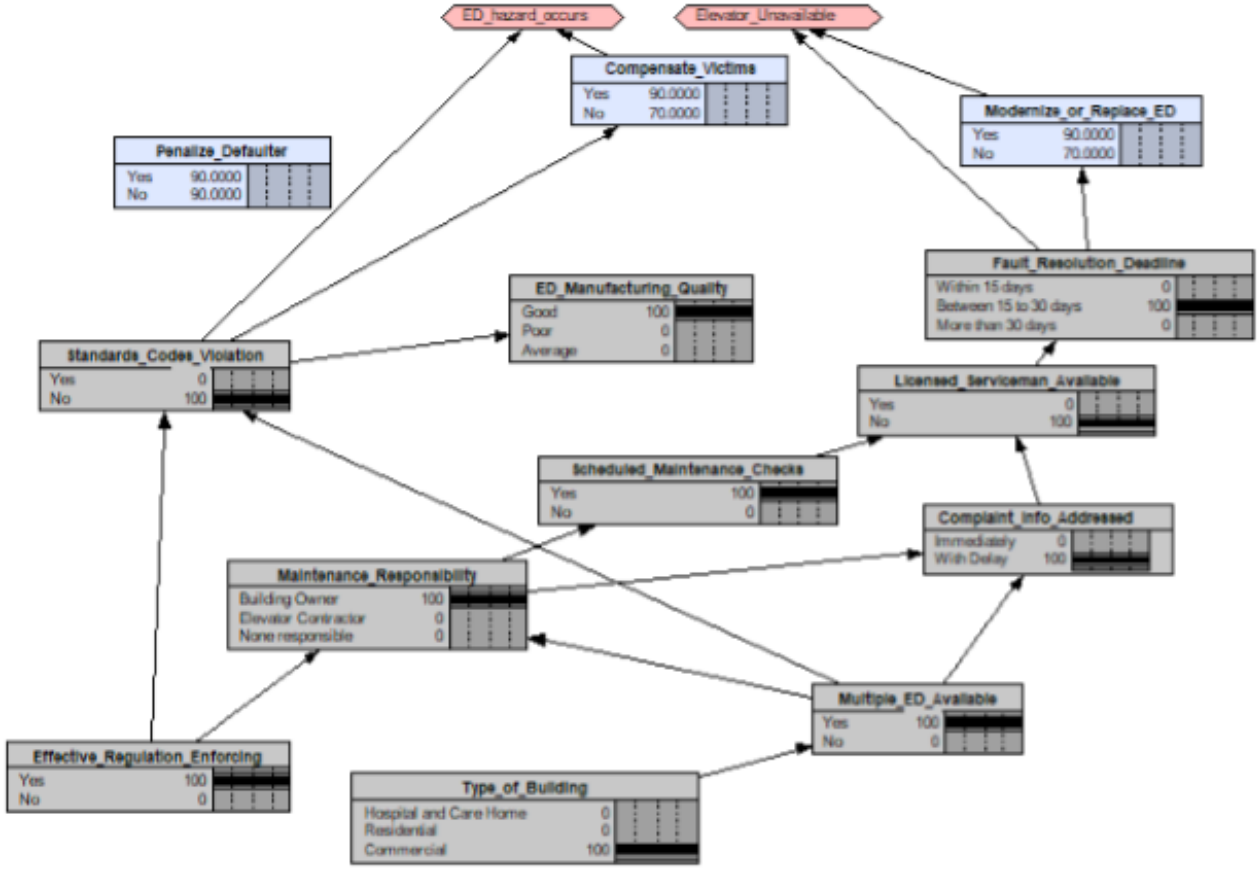
Scenarios and implications demo (4/4)

- More complex scenario



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Thank you! Any questions?

For more information…

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