TRANSPORT POLICY RESEARCH

Integrating Uncertainty into Transport Policy Evaluation: A Stratified Multi-Criteria Decision Framework

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Workshop Presentation

THE CHALLENGE

Why Transport Policy Decisions Fail

Long-term consequences

Infrastructure decisions shape cities for decades — yet evaluation tools assume tomorrow mirrors today

Competing priorities

Economic efficiency, environmental goals, and social equity pull in different directions

Static evaluation trap

Traditional methods use fixed criteria weights — ignoring how priorities evolve

THE STAKES

The Cost of Ignoring Uncertainty

Policy Fragility

- Decisions optimised for today fail when contexts transform
- Events like recessions or elections reshape priorities fundamentally
- Misaligned policies become costly to replace

The Opportunity

- Explicitly model how criteria importance shifts across futures
- Identify policies robust to multiple plausible scenarios
- Reduce optimism bias in decision-making

THE SOLUTION

Stratified Multi-Criteria Decision Analysis

01

Layer Multiple Futures

Define scenarios representing plausible policy environments

02

Dynamic Weightings

Allow criteria importance to shift across different contexts

03

Probabilistic Events

Assign structured likelihoods to scenario combinations

04

Future-Aware MCDA

Integrate uncertainty directly into evaluation architecture

Key insight: Positioned at the intersection of MCDA and scenario planning

TRANSFORMATION

What Stratification Actually Changes

From

- ✕ One weighting vector
- ✕ Subjective guesses
- ✕ Static scoring
- ✕ Fragile rankings

To

- ✓ Many scenario-specific vectors
- ✓ Structured event-driven shifts
- ✓ Scenario-integrated evaluation
- ✓ Robust, resilient decisions

CONTRIBUTION

Five Concrete Contributions

1

Event-Responsive Criteria

Recognises that importance shifts with economic, political, and social change

2

Structured Uncertainty

Integrates future variability without over-complex probabilistic models

3

Bias Reduction

Diminishes influence of optimism and overconfidence in single forecasts

4

Robustness Testing

Ensures top alternatives remain strong across multiple plausible scenarios

5

Temporal Relevance

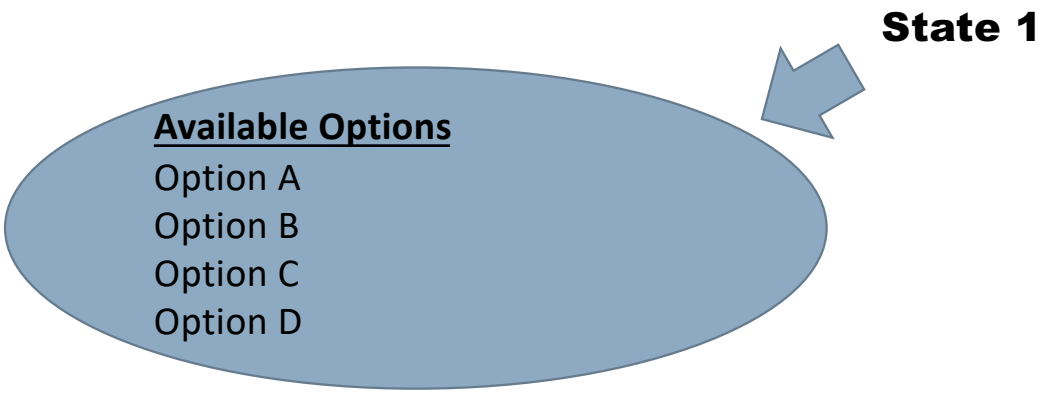
Makes MCDA genuinely fit for long-term infrastructure decisions

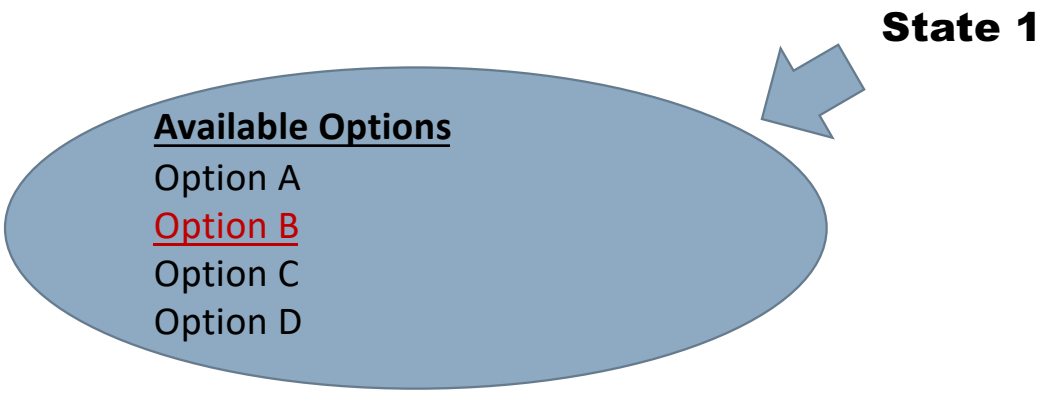
Novelty: Deliberate integration of established concepts to address a critical gap

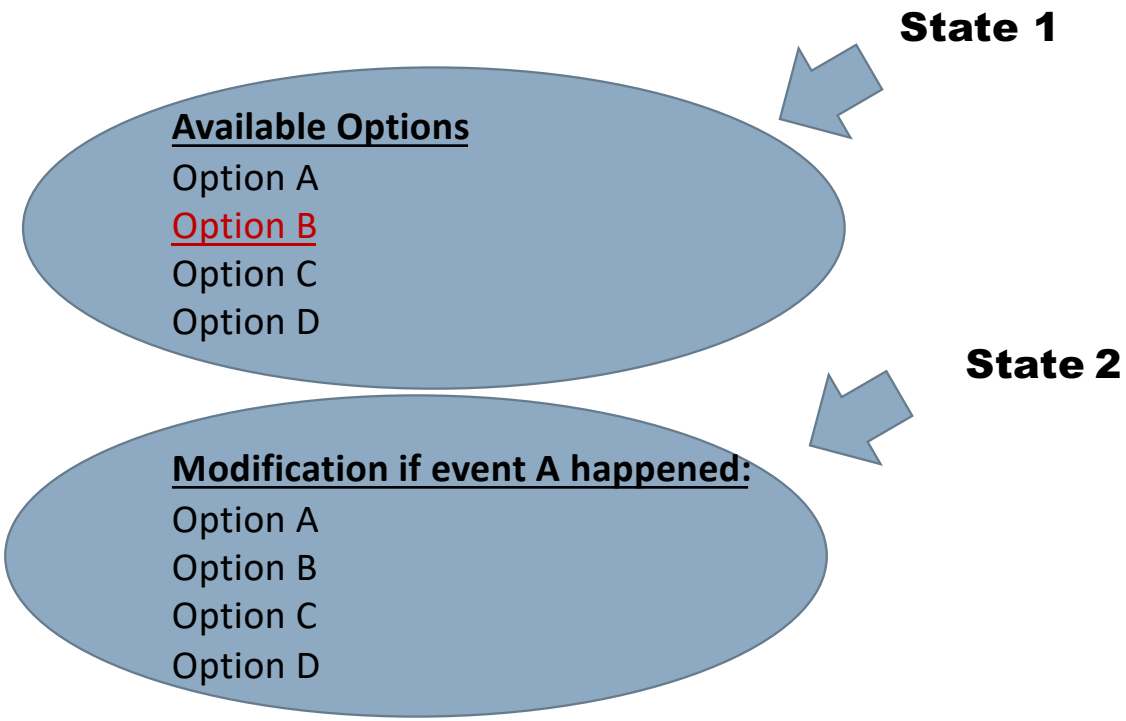
METHODOLOGY

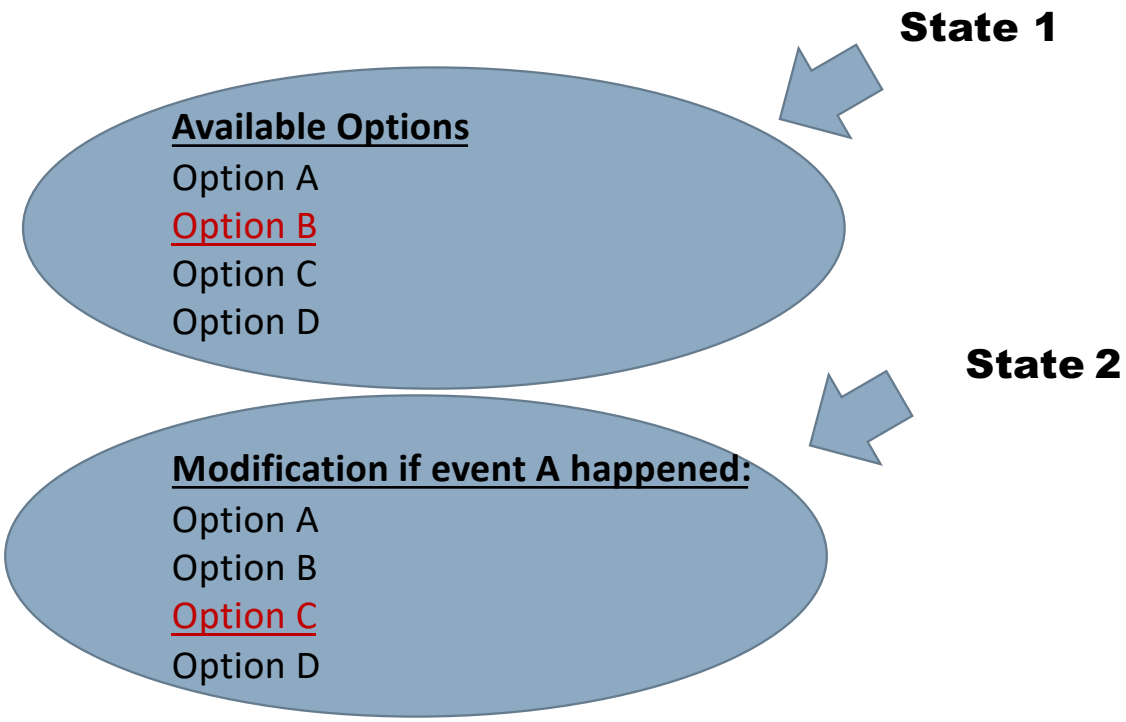
Ten-Step Stratified Framework

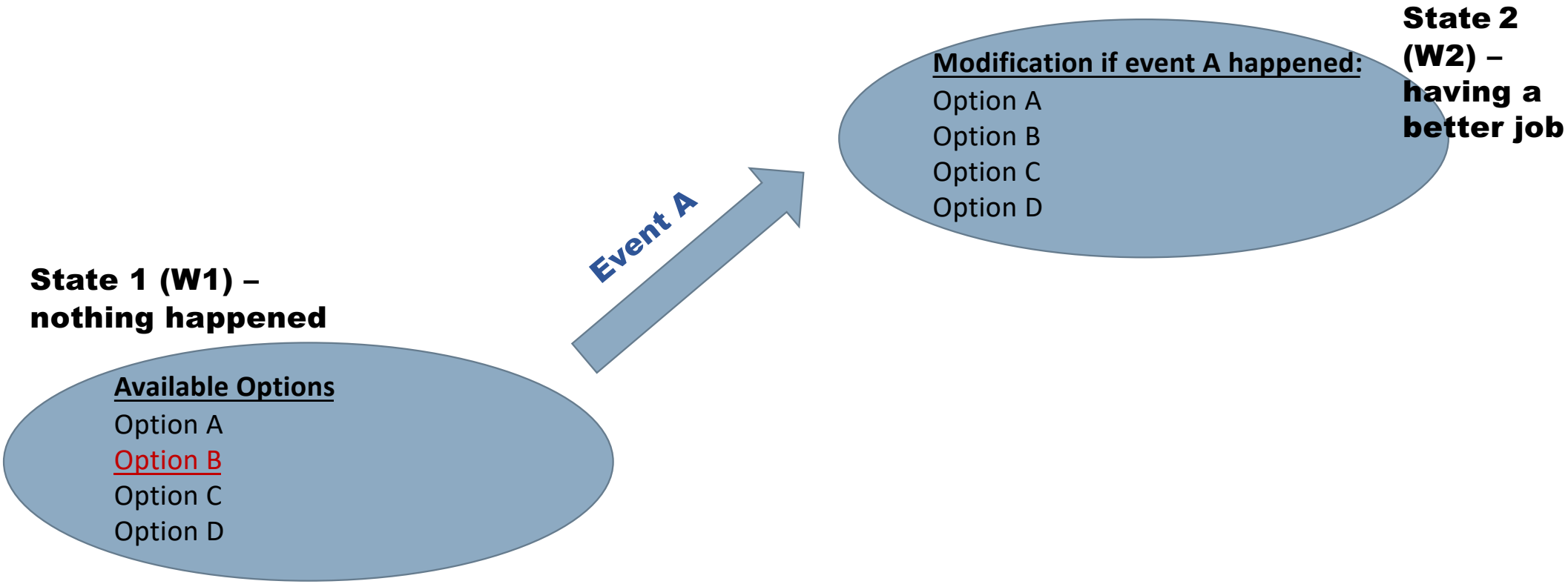
Two phases: Identification and Computational

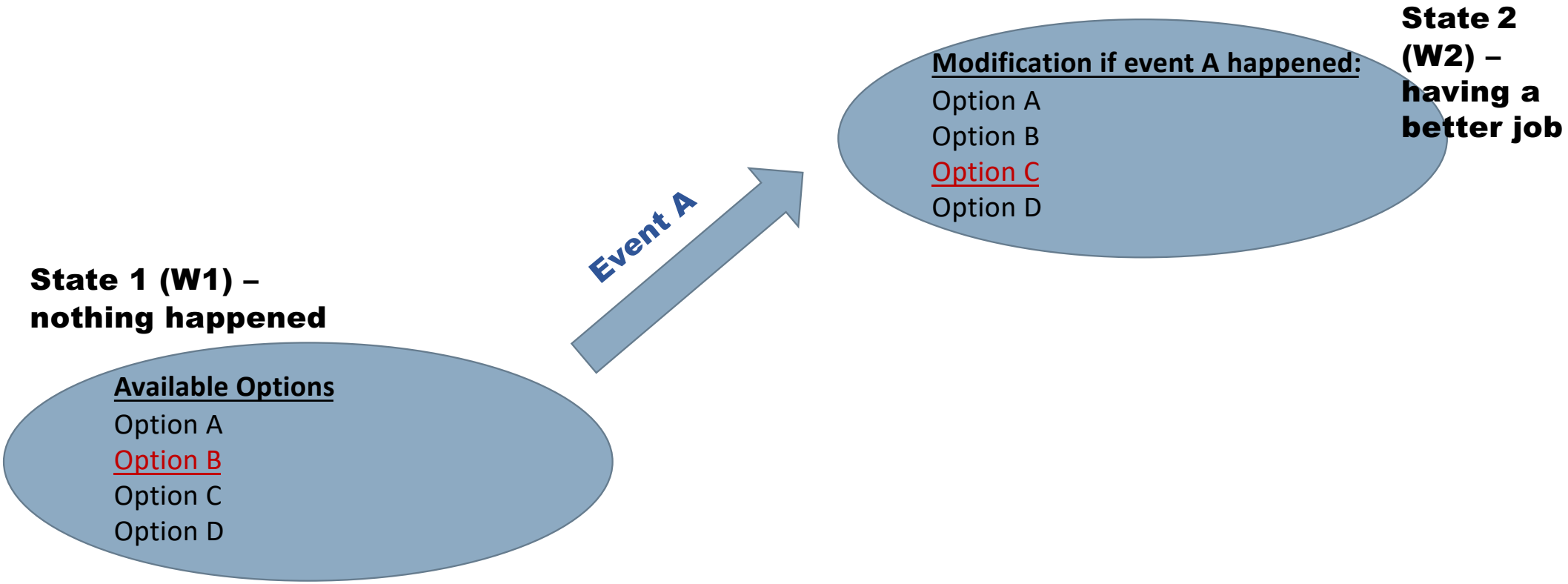

State 1
Available Options
Option A
Option B
Option C
Option D

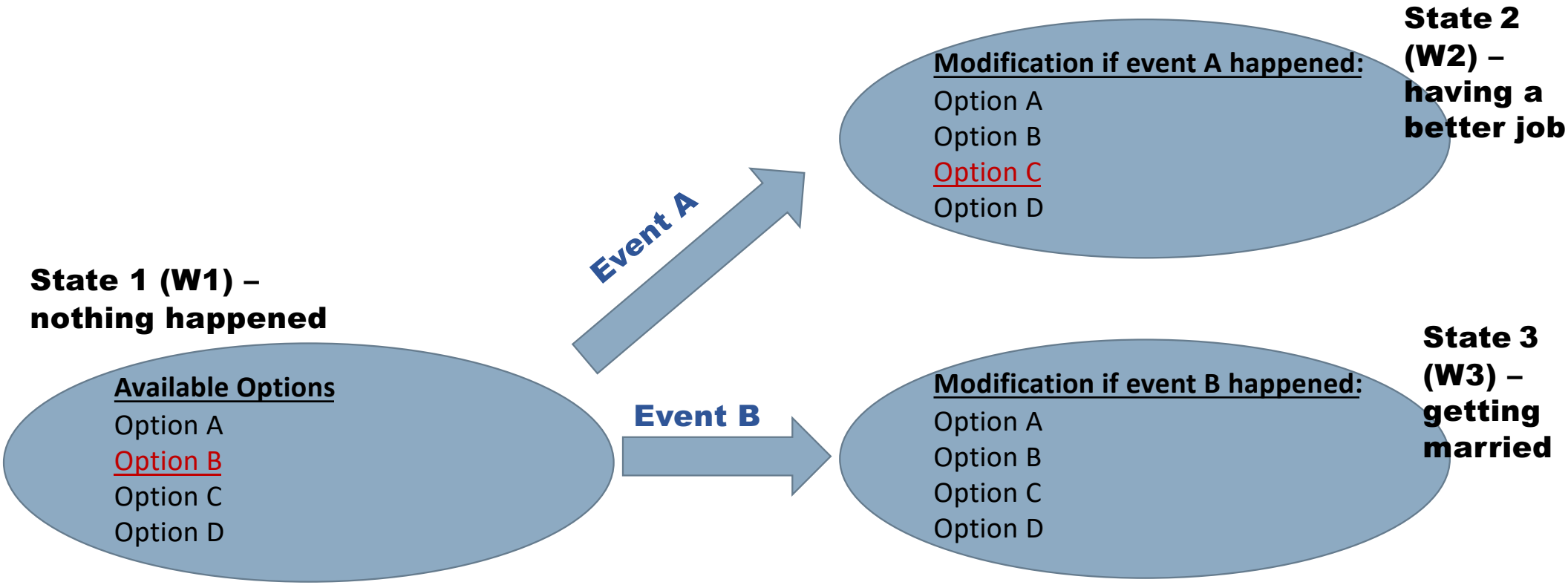

State 1
Available Options
Option A
Option B
Option C
Option D

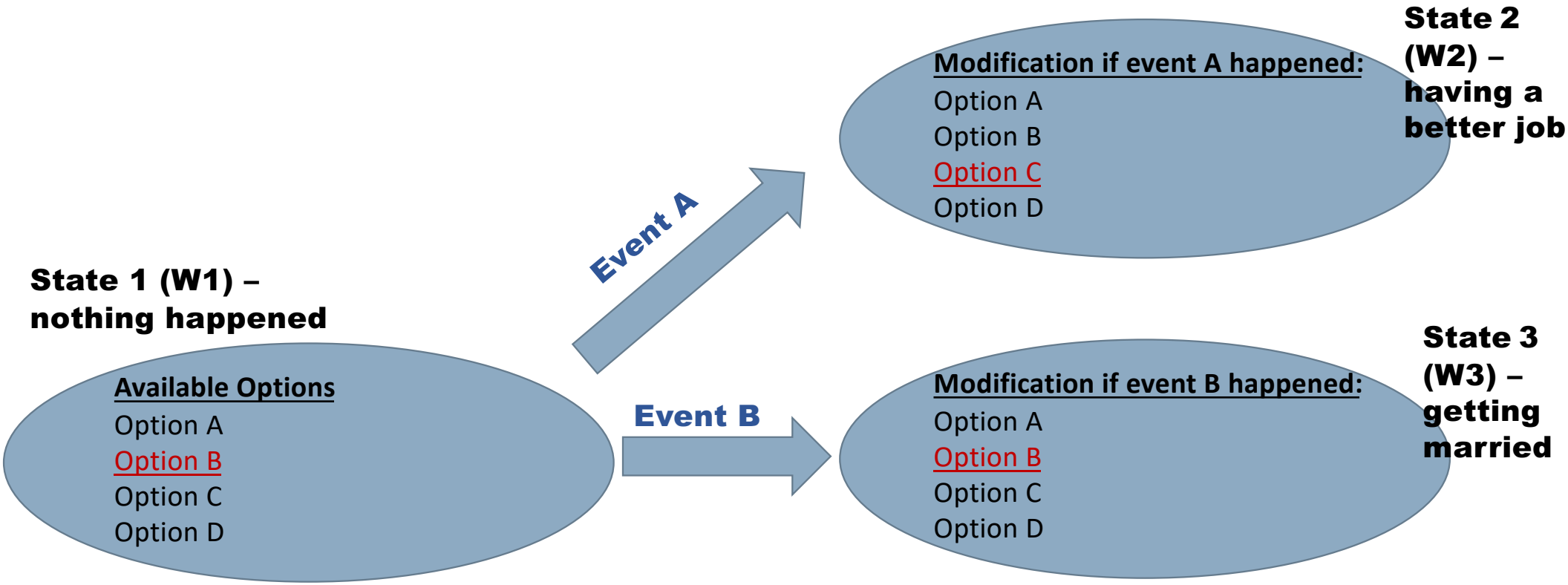

State 1
Available Options
Option A
Option B
Option C
Option D
State 2
Modification if event A happened:
Option A
Option B
Option C
Option D

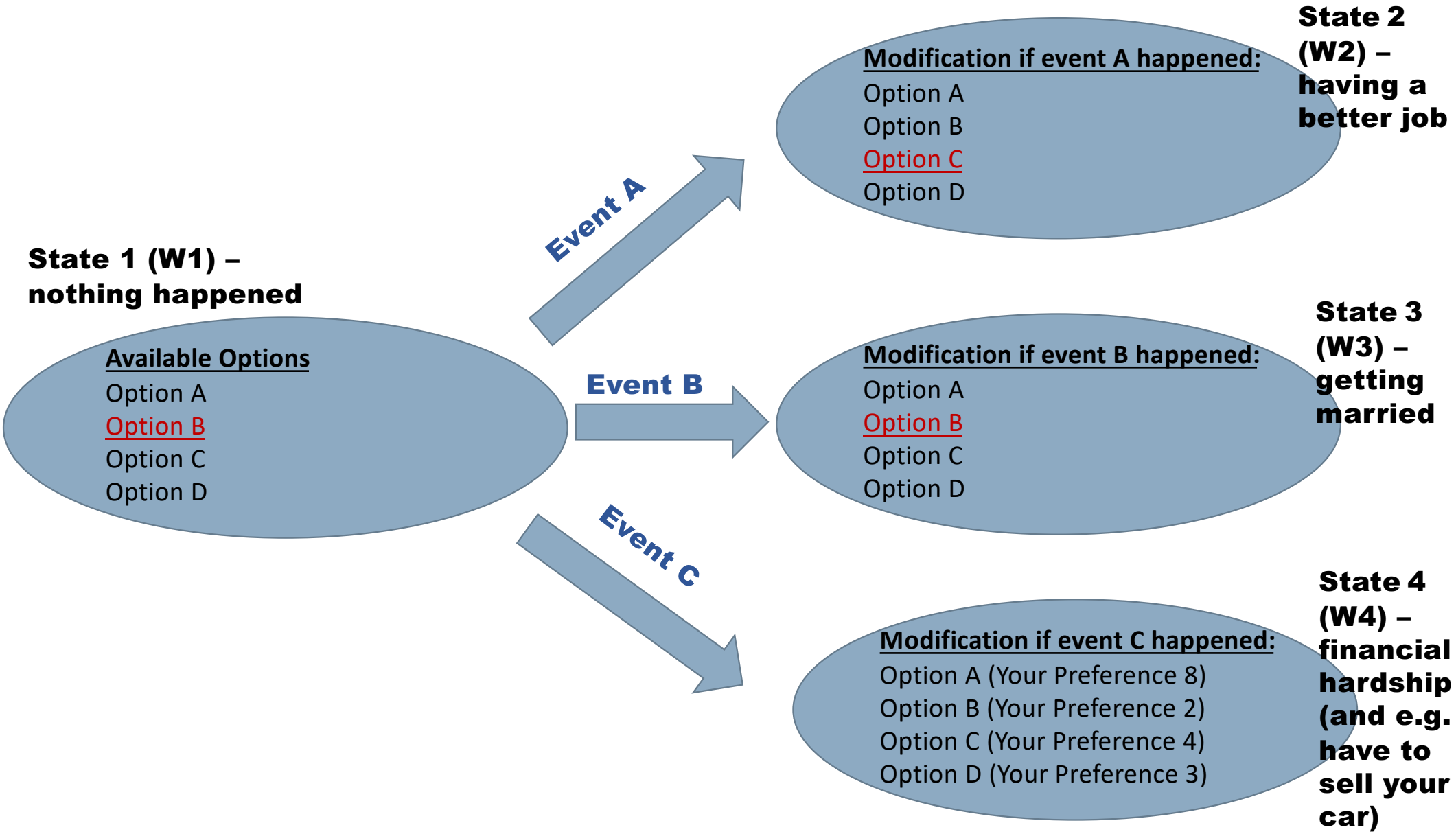

State 1
Available Options
Option A
Option B
Option C
Option D
State 2
Modification if event A happened:
Option A
Option B
Option C
Option D

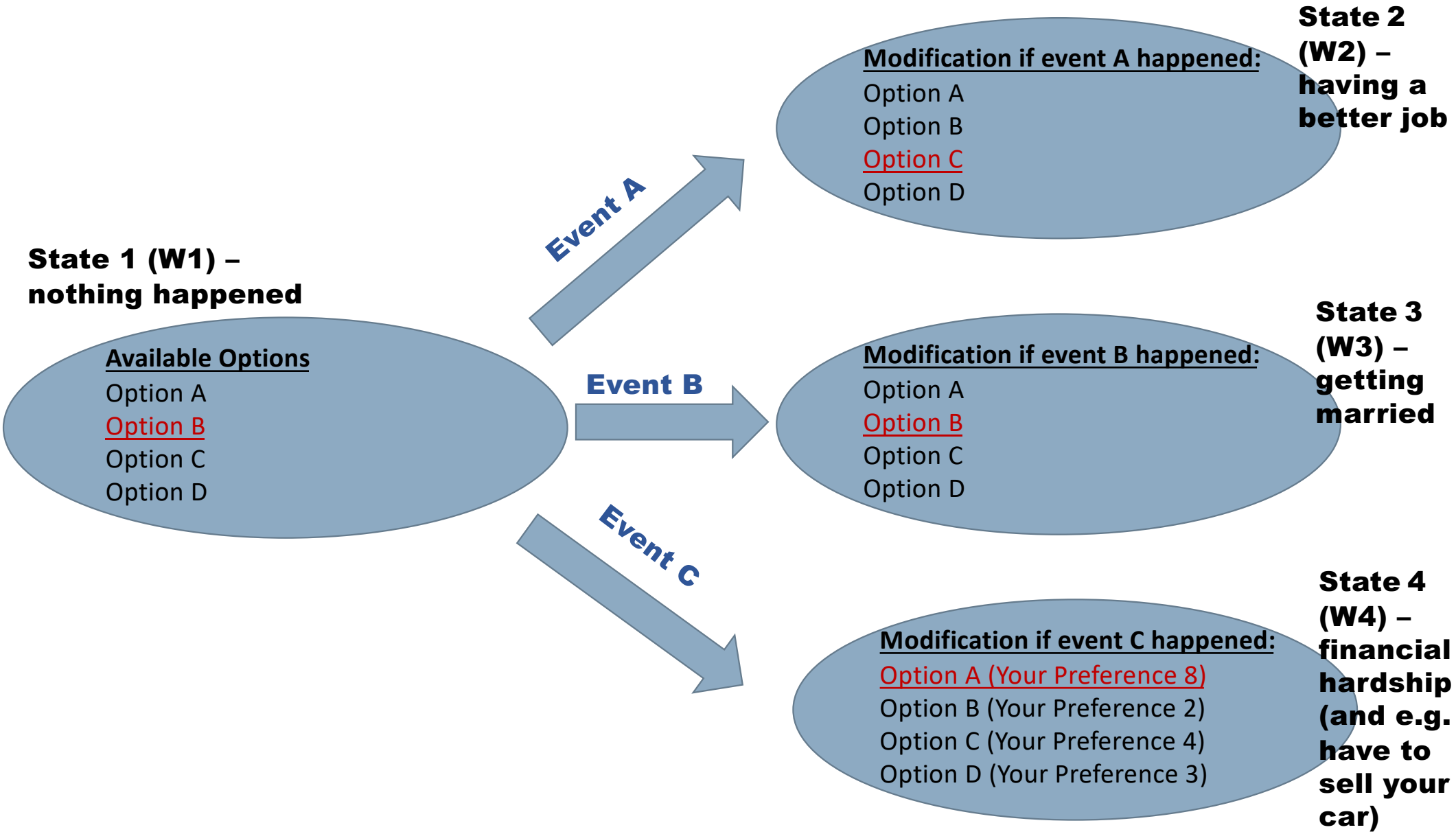

State 2 (W2) – having a better job
Modification if event A happened:
Option A
Option B
Option C
Option D
Event A
State 1 (W1) – nothing happened
Available Options
Option A
Option B
Option C
Option D

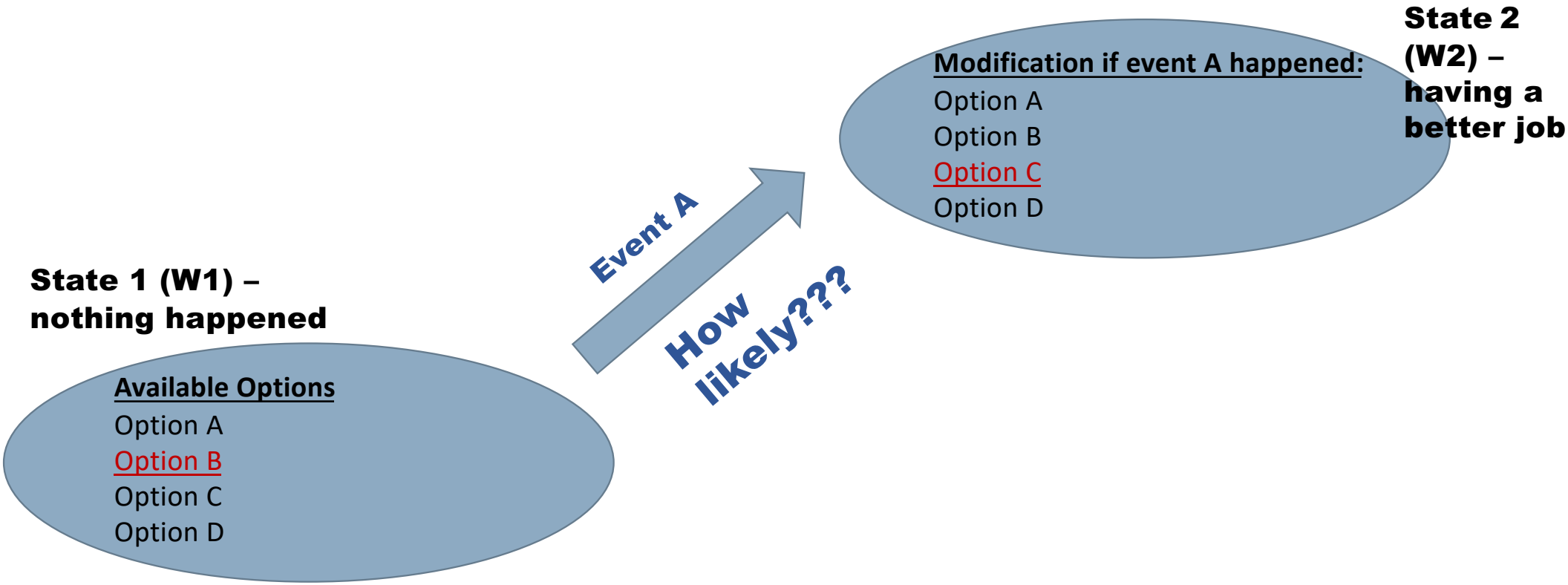

State 2 (W2) – having a better job
Modification if event A happened:
Option A
Option B
Option C
Option D
Event A
State 1 (W1) – nothing happened
Available Options
Option A
Option B
Option C
Option D

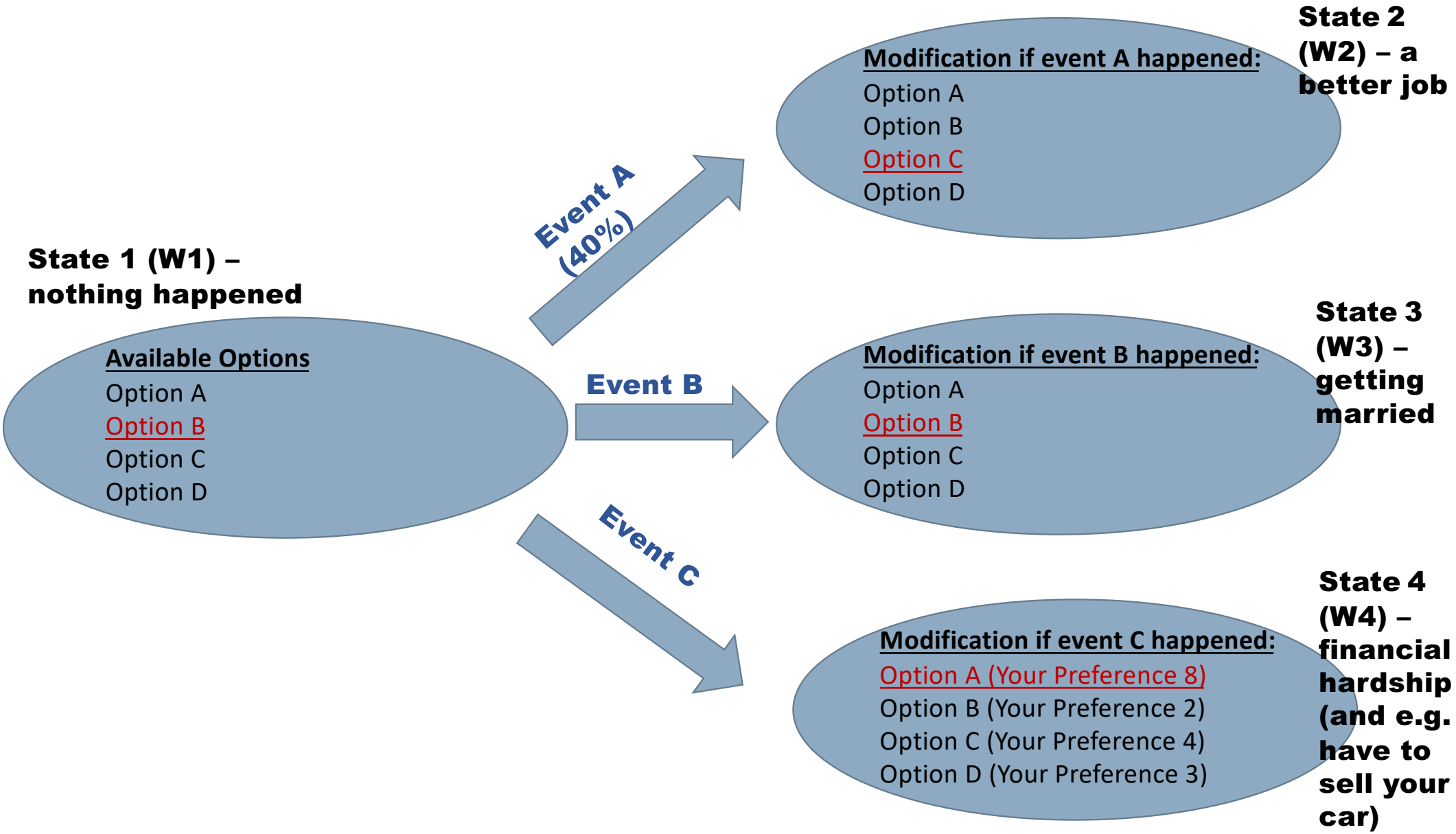

State 1 (W1) – nothing happened
Available Options
Option A
Option B
Option C
Option D
Event A
Modification if event A happened:
Option A
Option B
Option C
Option D
State 2 (W2) – having a better job
Event B
Modification if event B happened:
Option A
Option B
Option C
Option D
State 3 (W3) – getting married

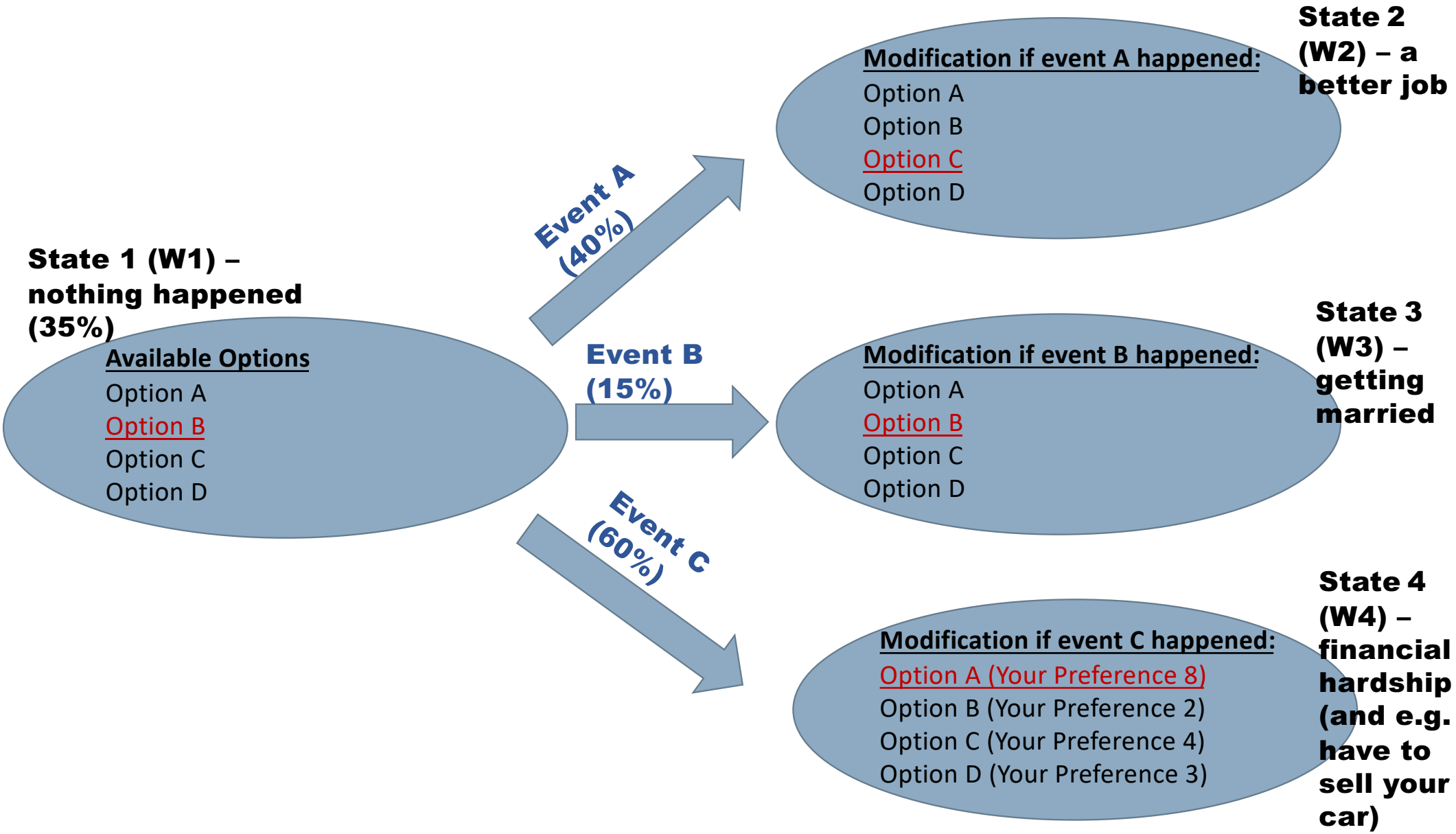

State 1 (W1) – nothing happened
Available Options
Option A
Option B
Option C
Option D
Event A
Modification if event A happened:
Option A
Option B
Option C
Option D
State 2 (W2) – having a better job
Event B
Modification if event B happened:
Option A
Option B
Option C
Option D
State 3 (W3) – getting married

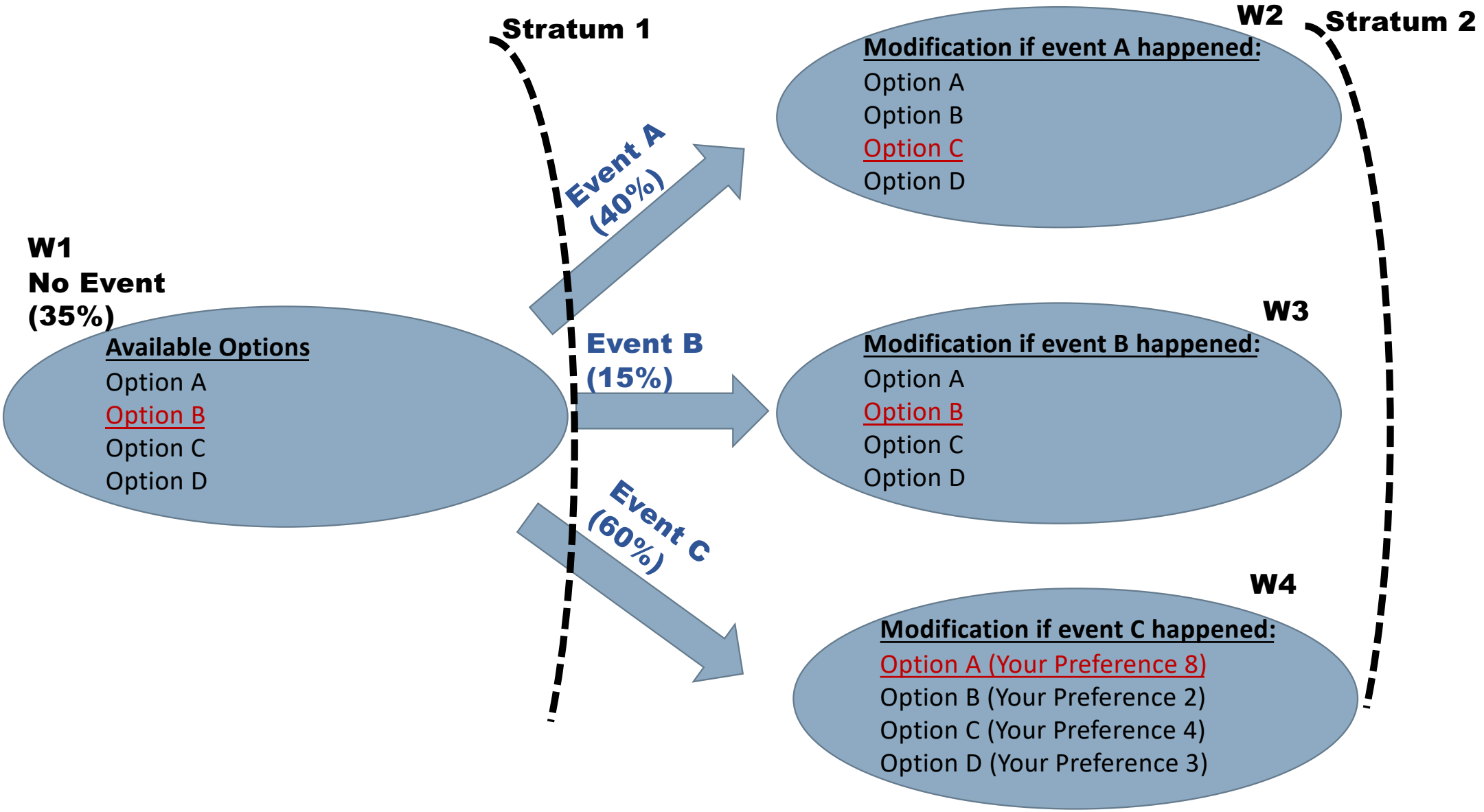

State 1 (W1) – nothing happened
Available Options
Option A
Option B
Option C
Option D
Event A
Event B
Event C
Modification if event A happened:
Option A
Option B
Option C
Option D
State 2 (W2) – having a better job
Modification if event B happened:
Option A
Option B
Option C
Option D
State 3 (W3) – getting married
Modification if event C happened:
Option A (Your Preference 8)
Option B (Your Preference 2)
Option C (Your Preference 4)
Option D (Your Preference 3)
State 4 (W4) – financial hardship (and e.g. have to sell your car)

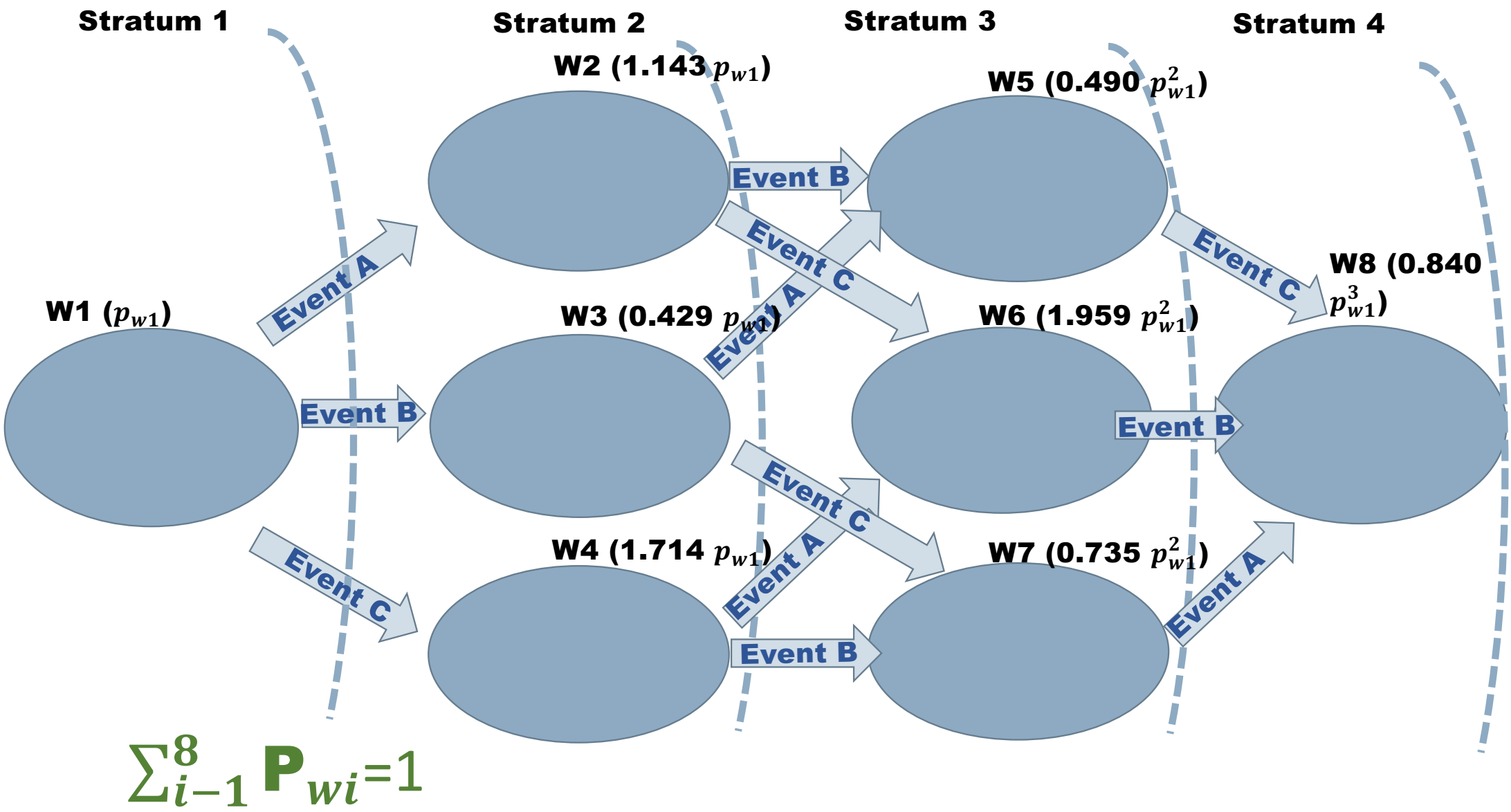

State 1 (W1) – nothing happened
Available Options
Option A
Option B
Option C
Option D
Event A
Modification if event A happened:
Option A
Option B
Option C
Option D
State 2 (W2) – having a better job
Event B
Modification if event B happened:
Option A
Option B
Option C
Option D
State 3 (W3) – getting married
Event C
Modification if event C happened:
Option A (Your Preference 8)
Option B (Your Preference 2)
Option C (Your Preference 4)
Option D (Your Preference 3)
State 4 (W4) – financial hardship (and e.g. have to sell your car)


State 2 (W2) – having a better job
Modification if event A happened:
Option A
Option B
Option C
Option D
Event A
How likely???
State 1 (W1) – nothing happened
Available Options
Option A
Option B
Option C
Option D

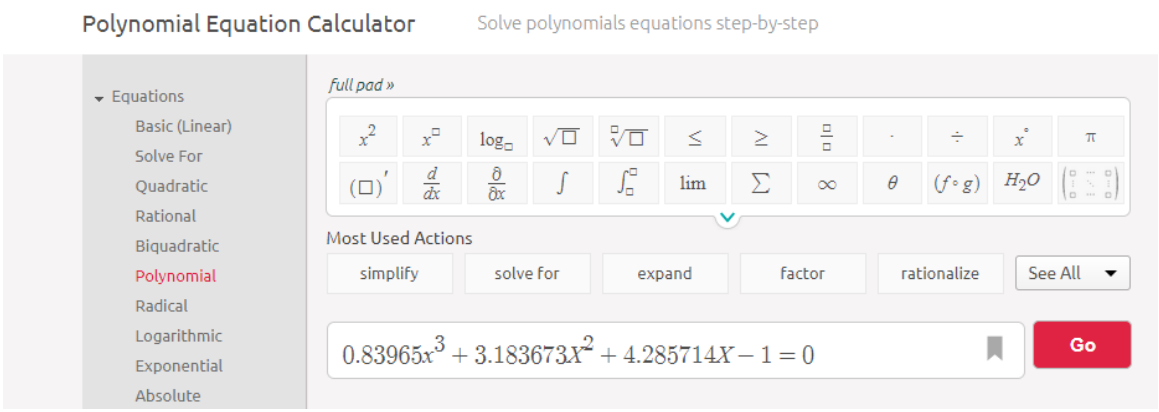

State 1 (W1) – nothing happened
Available Options
Option A
Option B
Option C
Option D
Event A (40%)
Event B
Event C
Modification if event A happened:
Option A
Option B
Option C
Option D
State 2 (W2) – a better job
Modification if event B happened:
Option A
Option B
Option C
Option D
State 3 (W3) – getting married
Modification if event C happened:
Option A (Your Preference 8)
Option B (Your Preference 2)
Option C (Your Preference 4)
Option D (Your Preference 3)
State 4 (W4) – financial hardship (and e.g. have to sell your car)


State 1 (W1) – nothing happened (35%)
Available Options
Option A
Option B
Option C
Option D
Event A (40%)
Event B (15%)
Event C (60%)
Modification if event A happened:
Option A
Option B
Option C
Option D
State 2 (W2) – a better job
Modification if event B happened:
Option A
Option B
Option C
Option D
State 3 (W3) – getting married
Modification if event C happened:
Option A (Your Preference 8)
Option B (Your Preference 2)
Option C (Your Preference 4)
Option D (Your Preference 3)
State 4 (W4) – financial hardship (and e.g. have to sell your car)


Stratum 1
Stratum 2
W1
No Event
(35%)
Available Options
Option A
Option B
Option C
Option D
Event A
(40%)
Event B
(15%)
Event C
(60%)
W2
Modification if event A happened:
Option A
Option B
Option C
Option D
W3
Modification if event B happened:
Option A
Option B
Option C
Option D
W4
Modification if event C happened:
Option A (Your Preference 8)
Option B (Your Preference 2)
Option C (Your Preference 4)
Option D (Your Preference 3)



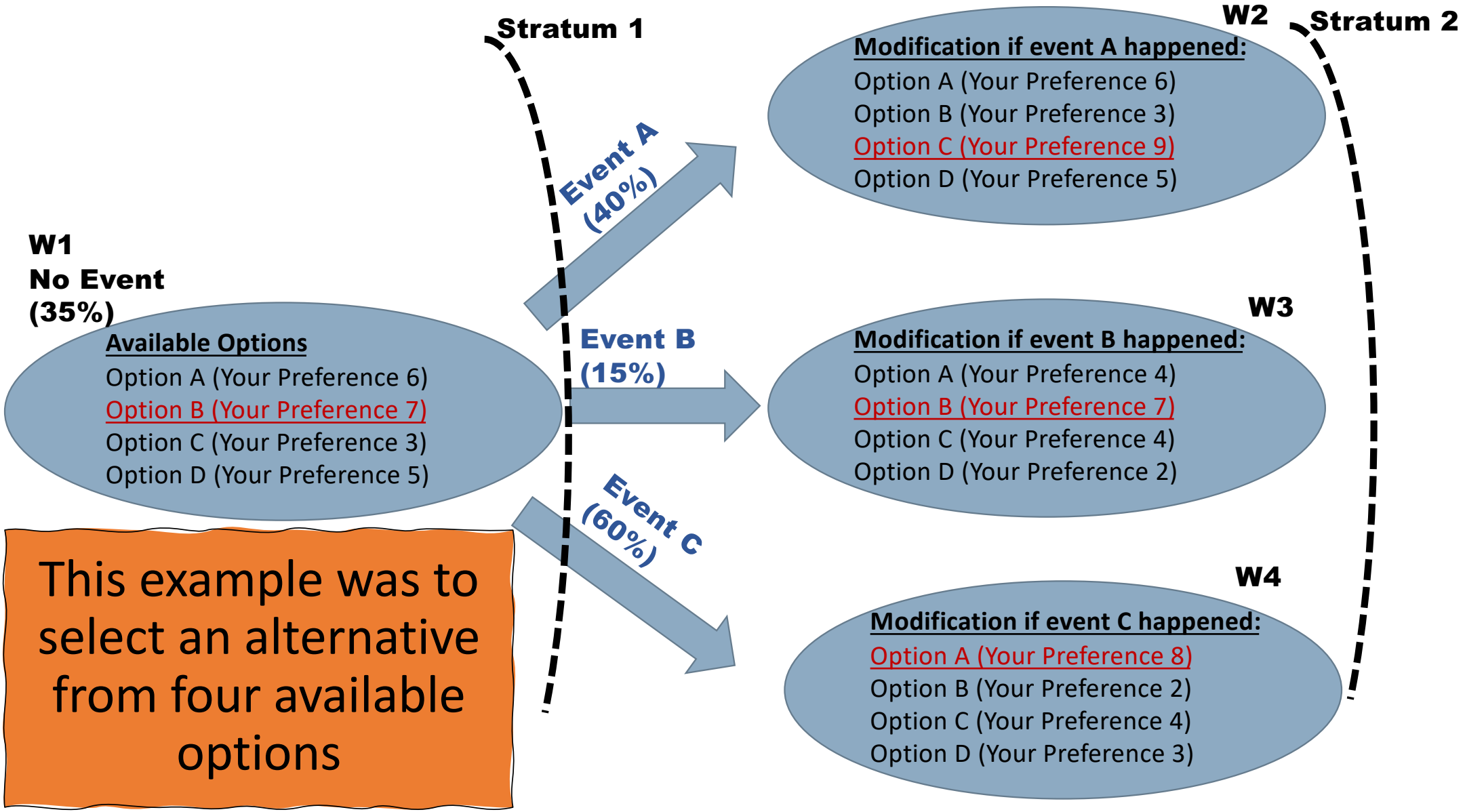
$$\sum_{i-1}^{8} \mathbf{P}_{wi}=1$$

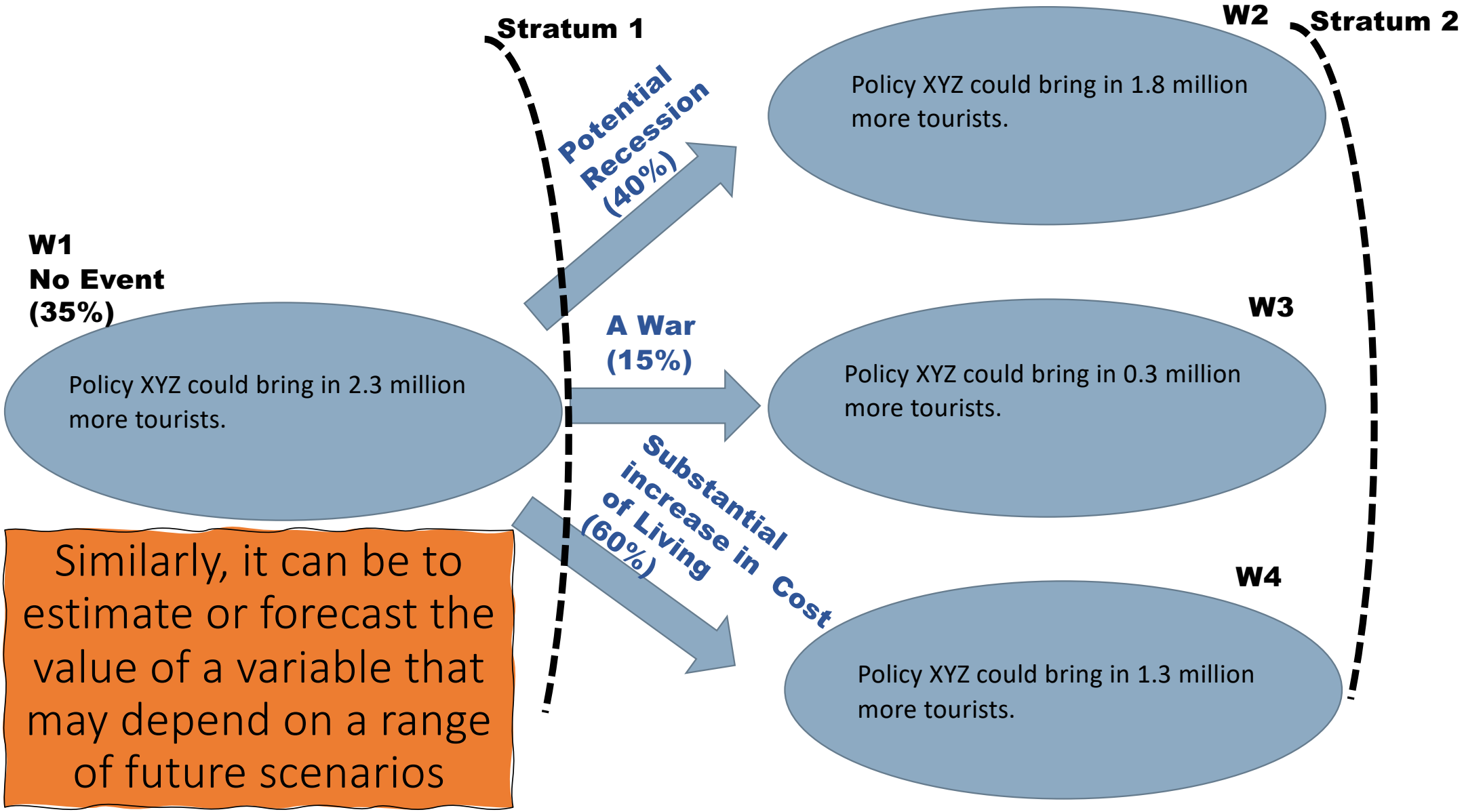


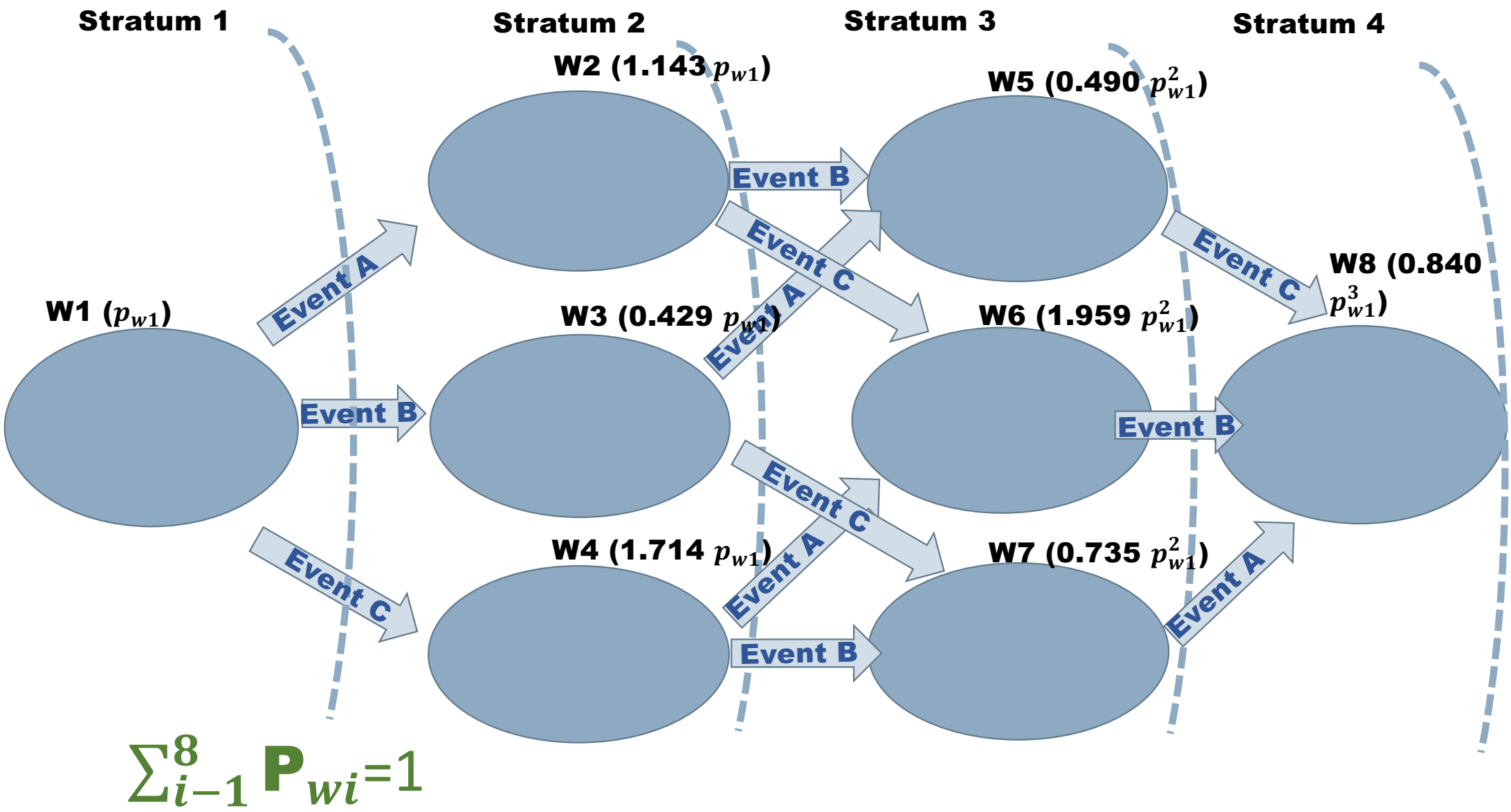
$$0.840\ P_1^3 + 3.184 P_1^2 + 4.286 P_1 - 1 = 0$$

$$P1 = 0.202$$

$$\begin{bmatrix} 0.30 & 0.40 & 0.40 & 0.35 & 0.40 & 0.37 & 0.38 & 0.38 \\ 0.30 & 0.40 & 0.25 & 0.20 & 0.33 & 0.30 & 0.22 & 0.30 \\ 0.40 & 0.20 & 0.35 & 0.45 & 0.27 & 0.33 & 0.40 & 0.32 \end{bmatrix} \times \begin{matrix} P_1 \\ P_2 \\ P_3 \\ P_4 \\ P_5 \\ P_6 \\ P_7 \\ P_8 \end{matrix} \begin{bmatrix} 0.202 \\ 0.230 \\ 0.086 \\ 0.346 \\ 0.020 \\ 0.080 \\ 0.030 \\ 0.007 \end{bmatrix}$$


Stratum 1
Stratum 2
W1
No Event
(35%)
Available Options
Option A (Your Preference 6)
Option B (Your Preference 7)
Option C (Your Preference 3)
Option D (Your Preference 5)
Event A
(40%)
Event B
(15%)
Event C
(60%)
W2
Modification if event A happened:
Option A (Your Preference 6)
Option B (Your Preference 3)
Option C (Your Preference 9)
Option D (Your Preference 5)
W3
Modification if event B happened:
Option A (Your Preference 4)
Option B (Your Preference 7)
Option C (Your Preference 4)
Option D (Your Preference 2)
W4
Modification if event C happened:
Option A (Your Preference 8)
Option B (Your Preference 2)
Option C (Your Preference 4)
Option D (Your Preference 3)
This example was to select an alternative from four available options


Stratum 1
W2
Stratum 2
Potential Recession (40%)
Policy XYZ could bring in 1.8 million more tourists.
W1
No Event
(35%)
Policy XYZ could bring in 2.3 million more tourists.
A War (15%)
W3
Policy XYZ could bring in 0.3 million more tourists.
Substantial increase in Cost of Living (60%)
W4
Policy XYZ could bring in 1.3 million more tourists.
Similarly, it can be to estimate or forecast the value of a variable that may depend on a range of future scenarios



$$\sum_{i-1}^{8} \mathbf{P}_{wi}=1$$

ILLUSTRATIVE FINDING

What the Perth Case Revealed

Classic MCDA Finding

Policy 1 appears optimal under static weights — but this assumes no significant events occur

Stratified MCDA Finding

Policy 3 emerges as most resilient across scenarios — stable performance in high-probability futures

Critical Insight

Only 10% probability of "no events" — yet static methods assume this is certain. Policy 1 collapses when uncertainty is acknowledged.

IMPLICATIONS

Decision-Maker Benefits

Reduces Optimism Bias

Forces consideration of less favourable but plausible futures

Stakeholder Consensus

Supports negotiation amongst diverse perspectives and priorities

Encourages Realism

Grounds analysis in event probabilities, not wishful projections

Facilitation Tool

Functions effectively in group decision-making contexts

Beyond analysis: Also serves as a practical facilitation tool in organisational settings

FINAL TAKEAWAY

When the Future Is Uncertain, the Method Must Adapt

Stratified MCDA is that adaptation

Completes traditional MCDA

Decisions that survive uncertainty

Robustness is the new efficiency

Thank you for your attention