Modeling Cooperative Lane-changing and Forced Merging Behavior

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February 10, 2006

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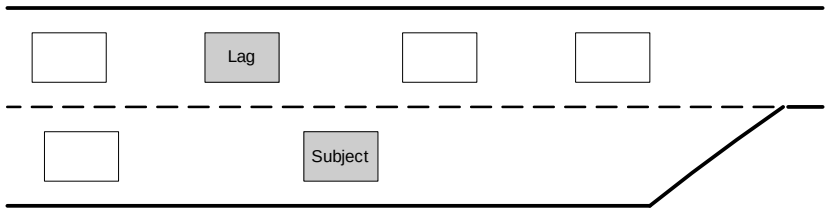
Outline

- Motivation
- Model structure
- Preliminary estimation results
- Next steps

Motivation

- Driving behavior models are key elements in microscopic traffic simulation tools
- Limitations of the state-of-the-art merging models
  - Based on reactive behavior
  - Ignore driver cooperation and courtesy
  - Forced merging modeled separately
- Applications of such models may result
  - Unrealistic traffic flow characteristics
  - Over predict congestion

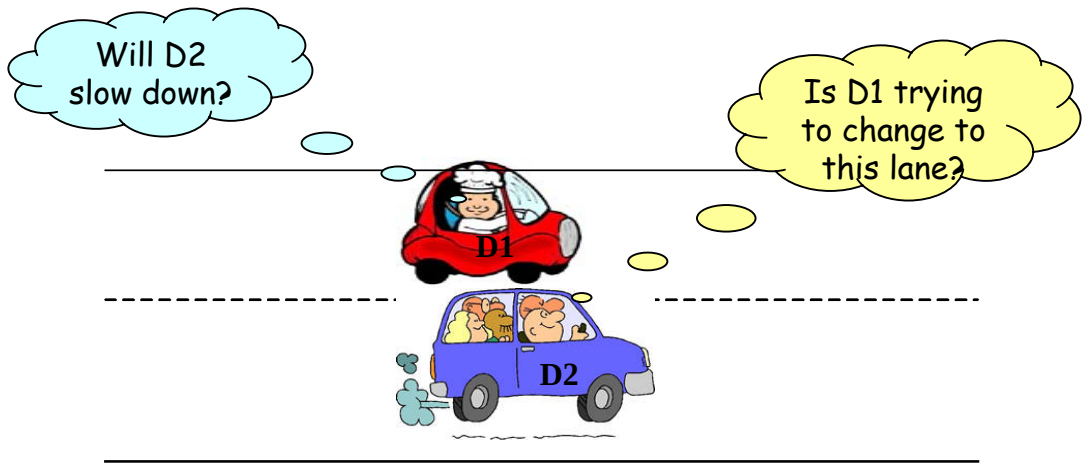
Merging Behavior



- Vehicle merging
  - Lane changing through gap acceptance
  - Models fail in dense traffic
- Additional merging mechanisms
  - Lag vehicle may provide courtesy
  - Vehicle may force a lane change

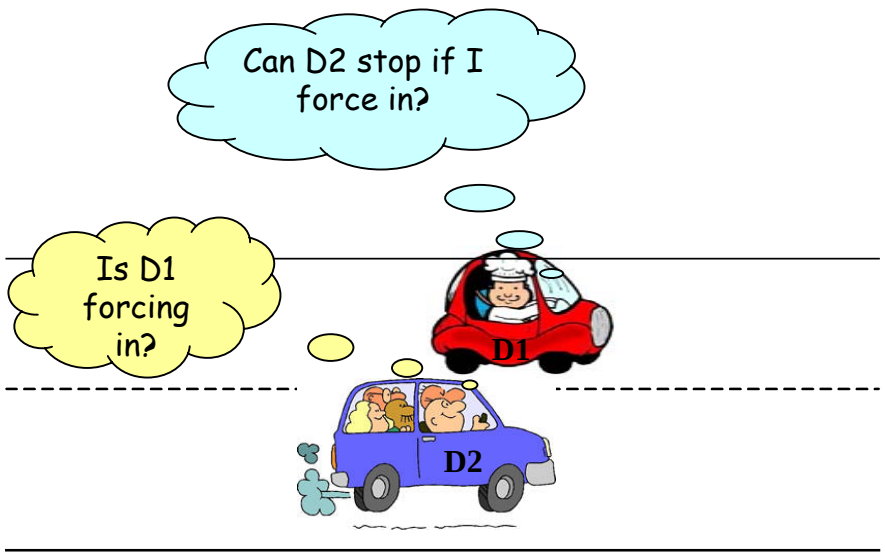
Proposed Model

- Explicitly includes anticipation of the behavior of other drivers in the decision making process of a particular driver
- Has the flexibility to capture cooperative behavior among drivers



Proposed Model (cont.)

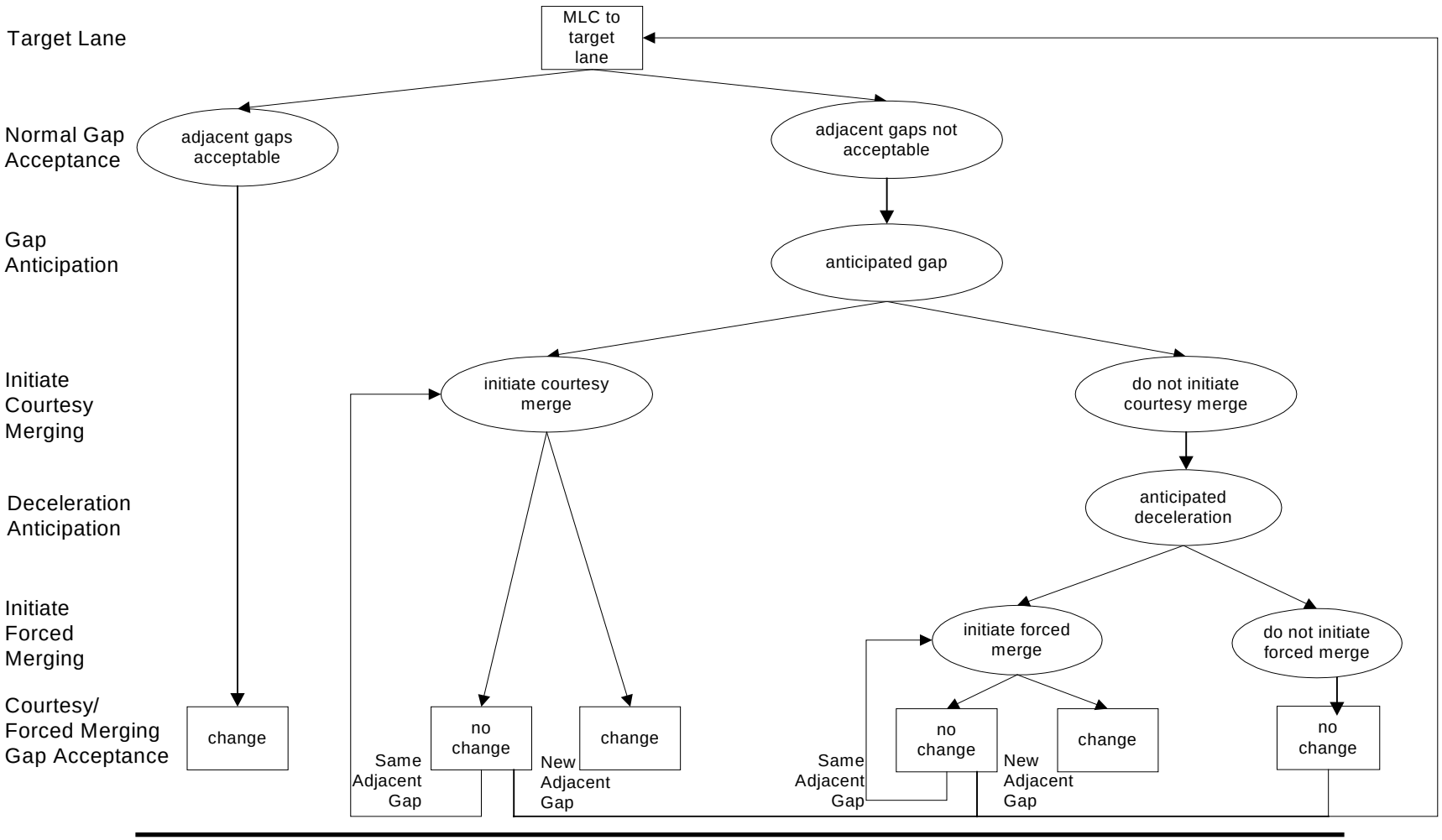
- Integrates forced merging in the general decision framework



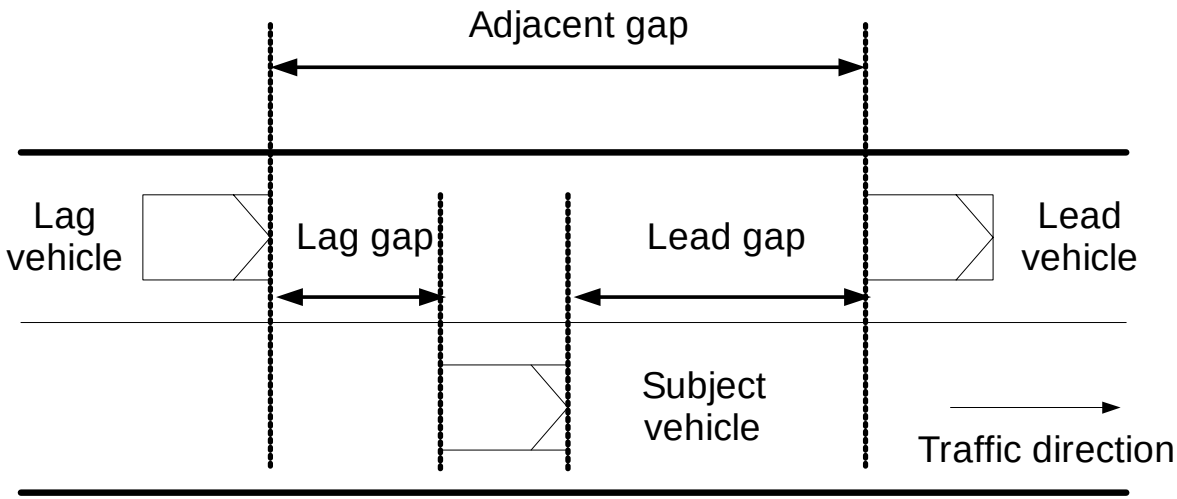
Proposed Model (cont.)

- Stochastic model with state dependency and serial correlation along a trajectory
- Transition from normal to cooperative or forced merge is endogenous

Framework

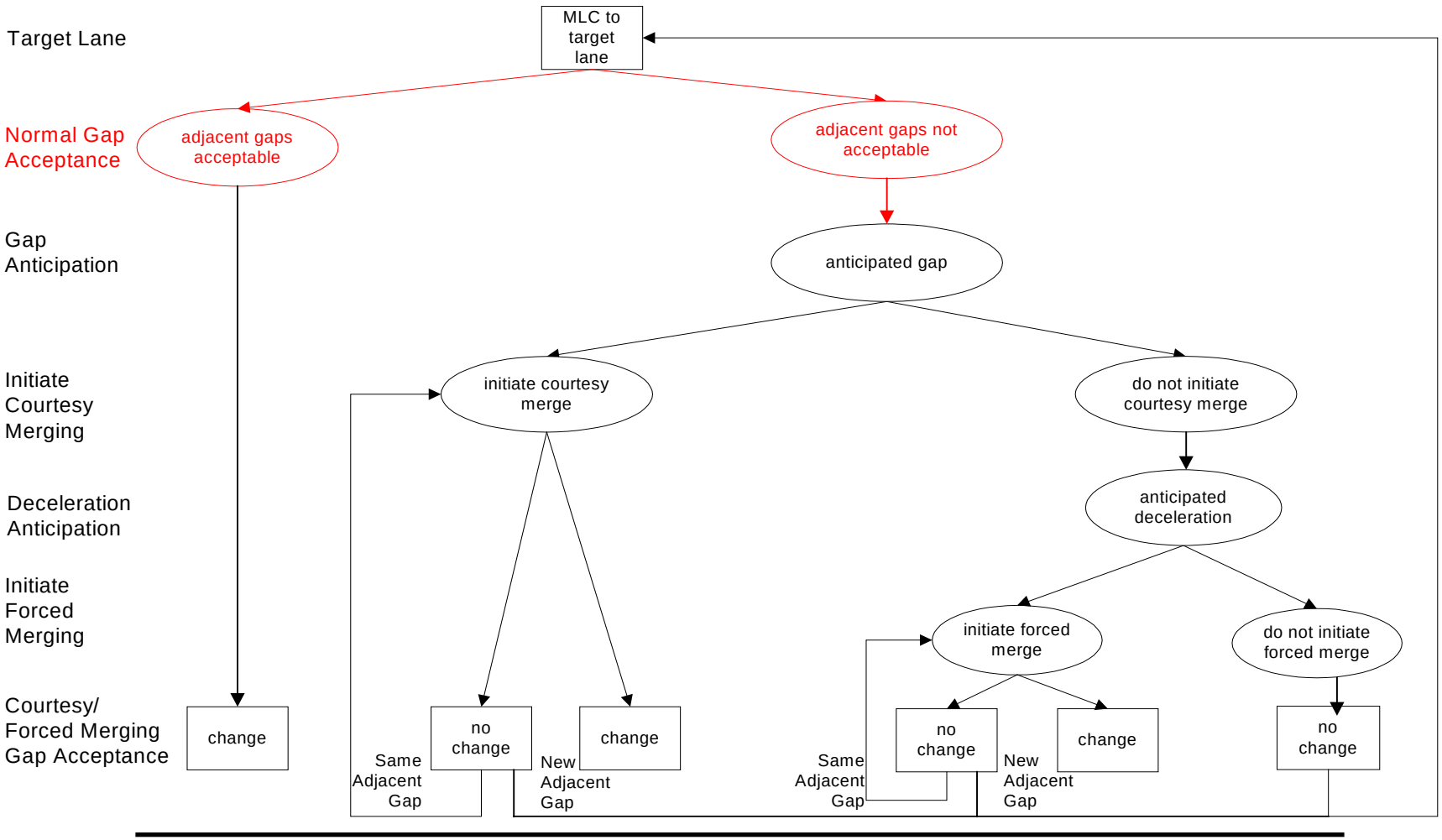

Target Lane
Normal Gap Acceptance
Gap Anticipation
Initiate Courtesy Merging
Deceleration Anticipation
Initiate Forced Merging
Courtesy/ Forced Merging Gap Acceptance
MLC to target lane
adjacent gaps acceptable
adjacent gaps not acceptable
anticipated gap
initiate courtesy merge
do not initiate courtesy merge
anticipated deceleration
initiate forced merge
do not initiate forced merge
change
no change
change
Same Adjacent Gap
New Adjacent Gap
no change
change
Same Adjacent Gap
New Adjacent Gap
no change

Available Gap



- Adjacent gap changes if either lead or lag vehicle changes

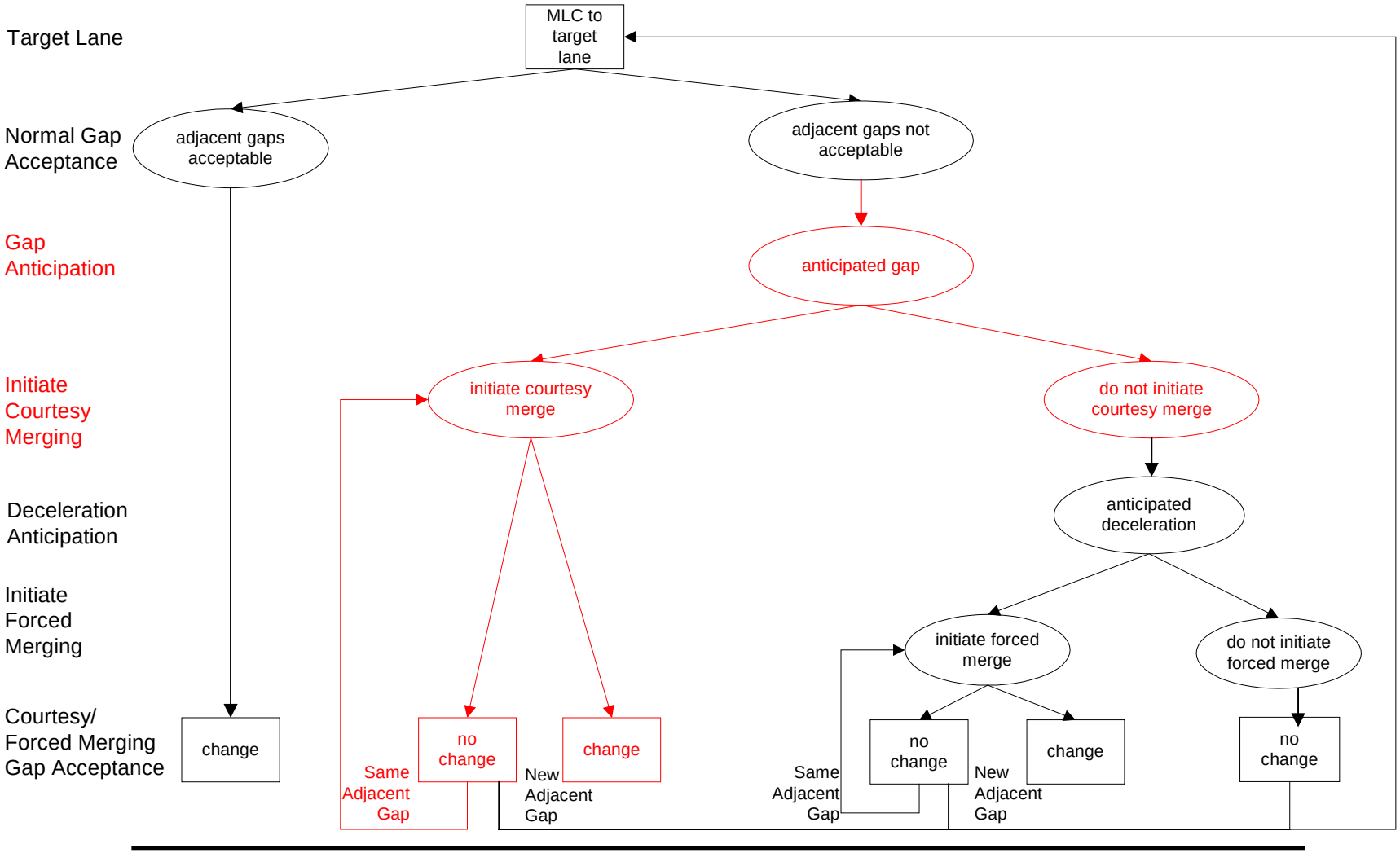
Gap Acceptance



Gap Acceptance (cont.)

- Target lane of the merging driver is the rightmost lane of the mainline
- Driver evaluates lead and lag gaps
- Changes lanes if both gaps are acceptable
- Acceptable gap
  - available gap >= critical gap

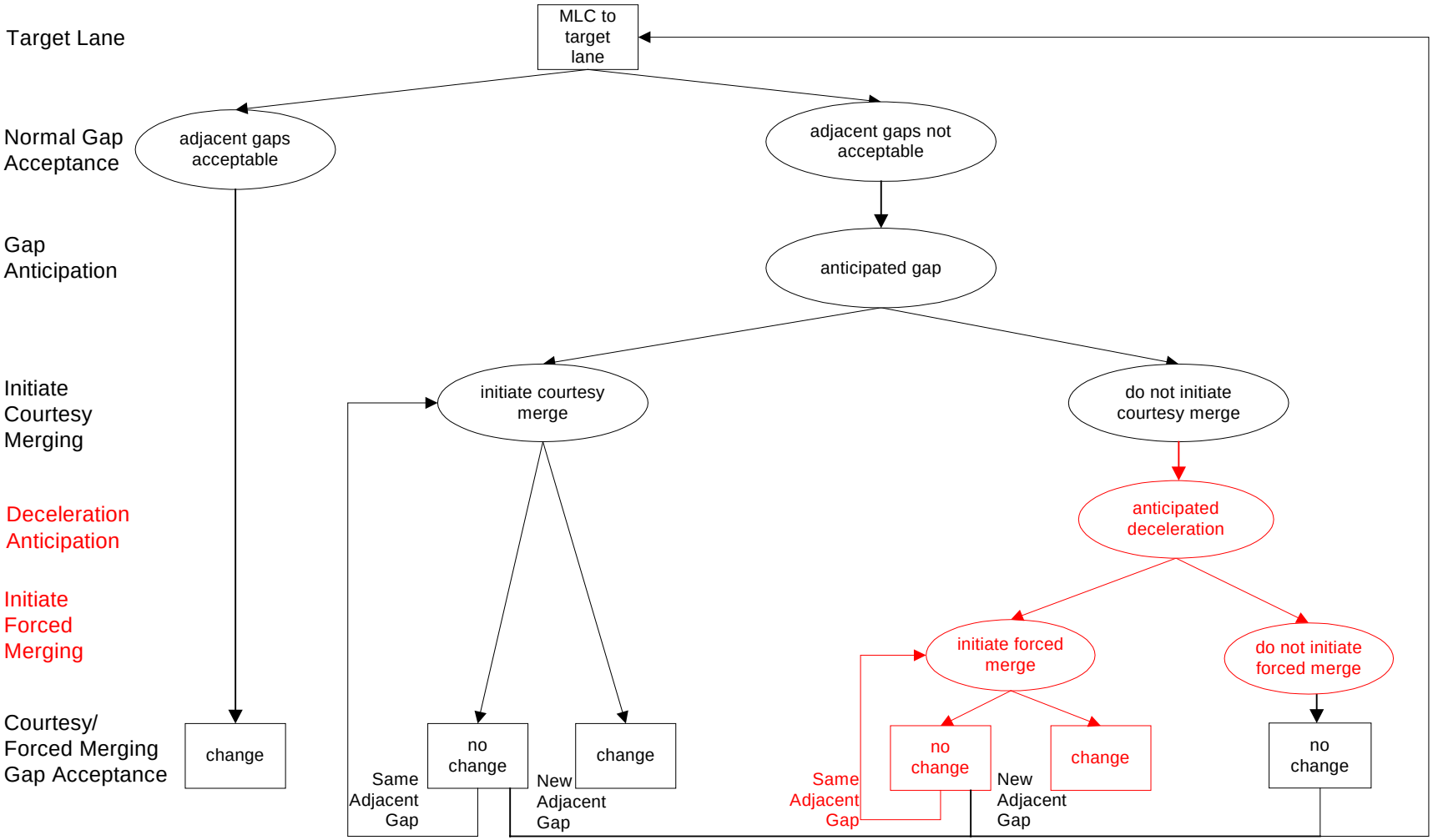
Courtesy Merging



Courtesy Merging (cont.)

- Driver anticipates future gap
  - Latent time horizon τ_n
- Critical gap may differ from normal gap acceptance
- Anticipated gap
  - Acceptable : Initiate lane change through courtesy
  - Not acceptable: Consider initiating forced merge
- Unacceptable available gaps may delay the execution of the courtesy lane change

Forced Merging



Forced Merging (cont.)

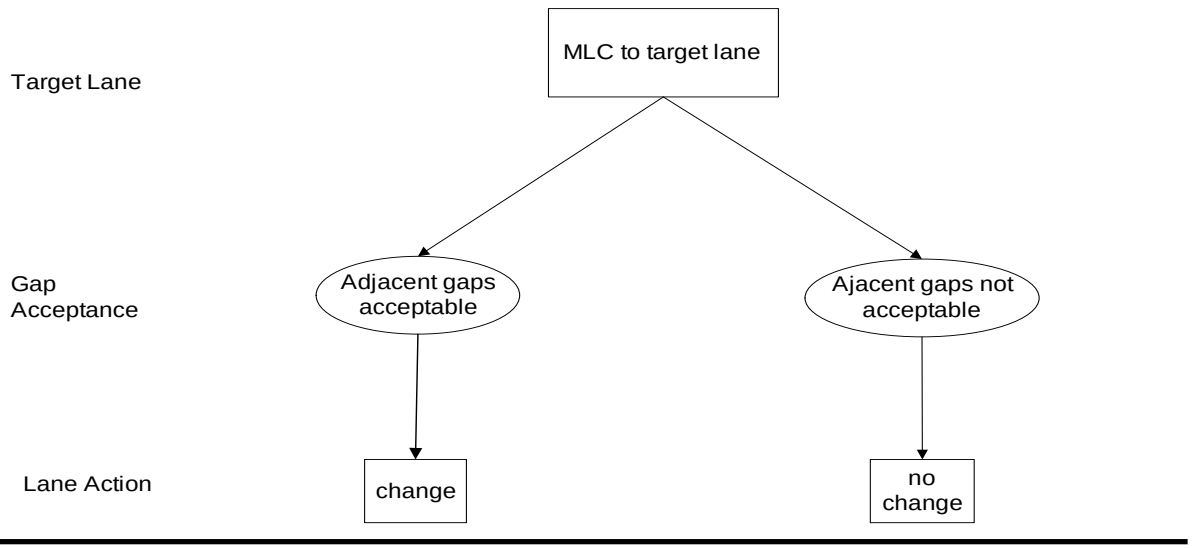
- Driver evaluates the feasibility to initiate a forced merge
  - Anticipated deceleration and stopping distance of the lag vehicle
- Anticipated deceleration/stopping distance
  - Acceptable: Initiate forced merge
  - Not acceptable: Remain in normal merging state
- Unacceptable available gaps may delay the execution of the forced lane change

Modeling Issues

- Can a simpler model be equally effective?
- Two simplified structures
  1. Combine all lane changing types in a one stage model including variables that capture courtesy and forced merging
  2. Combine normal and courtesy merging and treat only forced merging separately

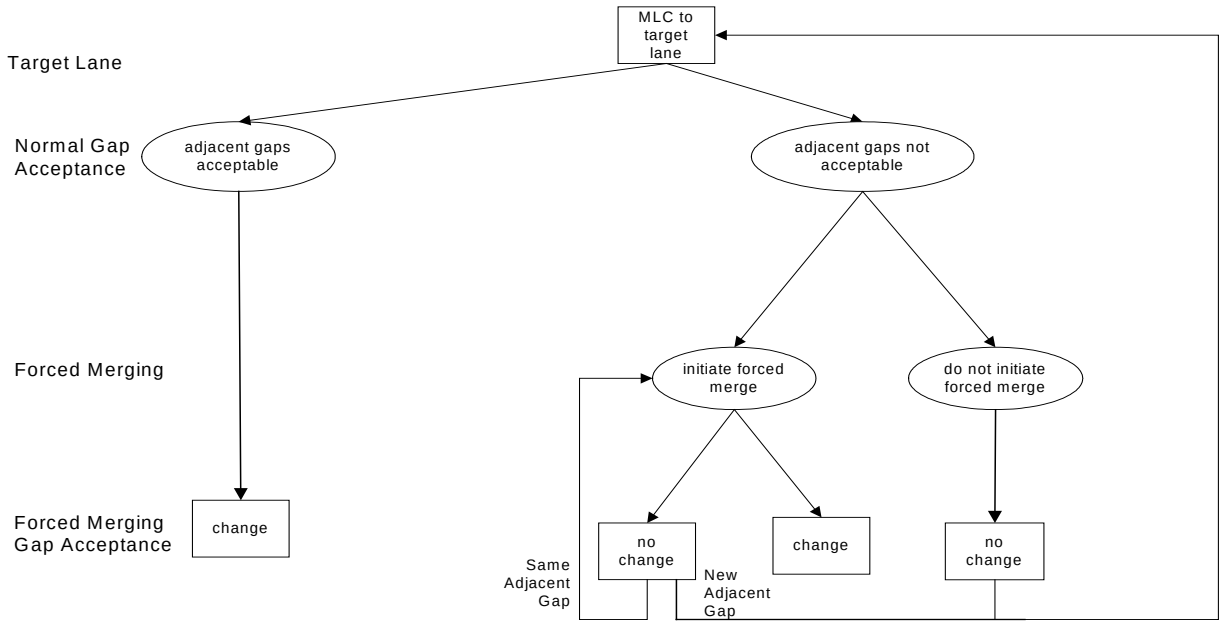
Alternative Model 1

- Maintain structure of gap acceptance models
  - Incorporate variables that capture courtesy and forcing
    - e.g. acceleration of lag vehicle, remaining distance to end of ramp, delay, density etc.

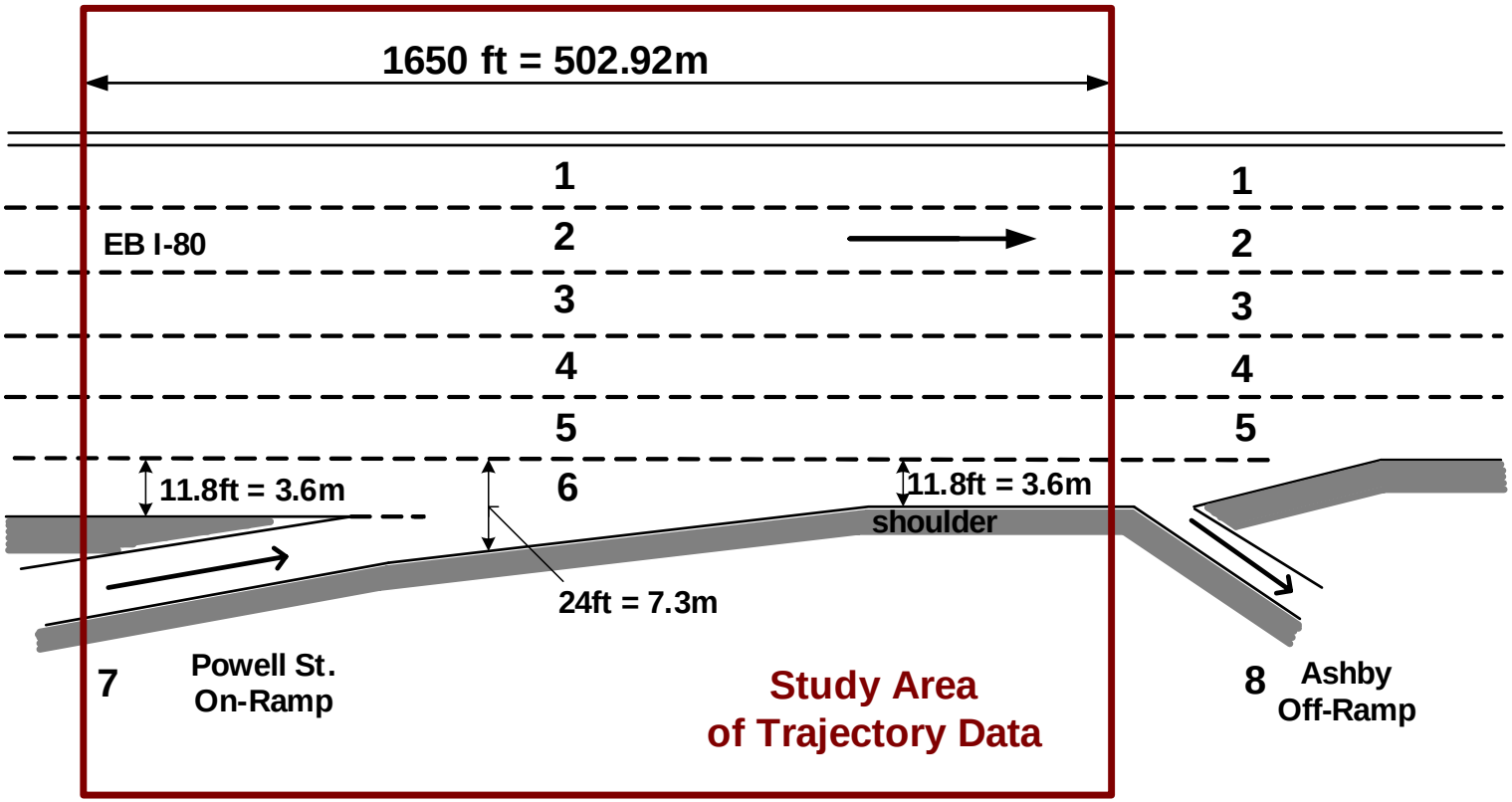


Alternative Model 2

- Explicitly model forced merging
- Capture courtesy via variables in gap acceptance model
  - e.g. acceleration of lag vehicle etc.



NGSIM I-80 Study Area



Estimation Data Set

- 45 minute data
- 592 merging vehicles
- X and Y coordinates every 1/10th sec
- Estimation based on 17230 observations
- Summary statistics
  - Average speed of merging vehicles 14.6 km/hr
  - Average speed in Lane 6 16.3 km/hr
  - Average density in Lane 6 68.2 veh/km/lane

Preliminary estimation results

- Critical lead and lag gaps
  - Decrease with remaining distance to end of ramp
  - Increase with average speed of the mainline and speed of lag vehicle
- Significantly better fit with more detailed model structures

Conclusion

- Next Steps
  - Implement in MITSIMLab
  - Calibrate and validate using aggregate sensor data
- Future Research
  - Incorporate
    - Target gap selection
    - Acceleration to facilitate merging

Questions?