Sustainable Built Environment National Research Centre

Curtin University

Australian Government
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Integrated Control Strategy for Variable Speed Limit (VSL) and Ramp Metering (RM)

-- Literature Review

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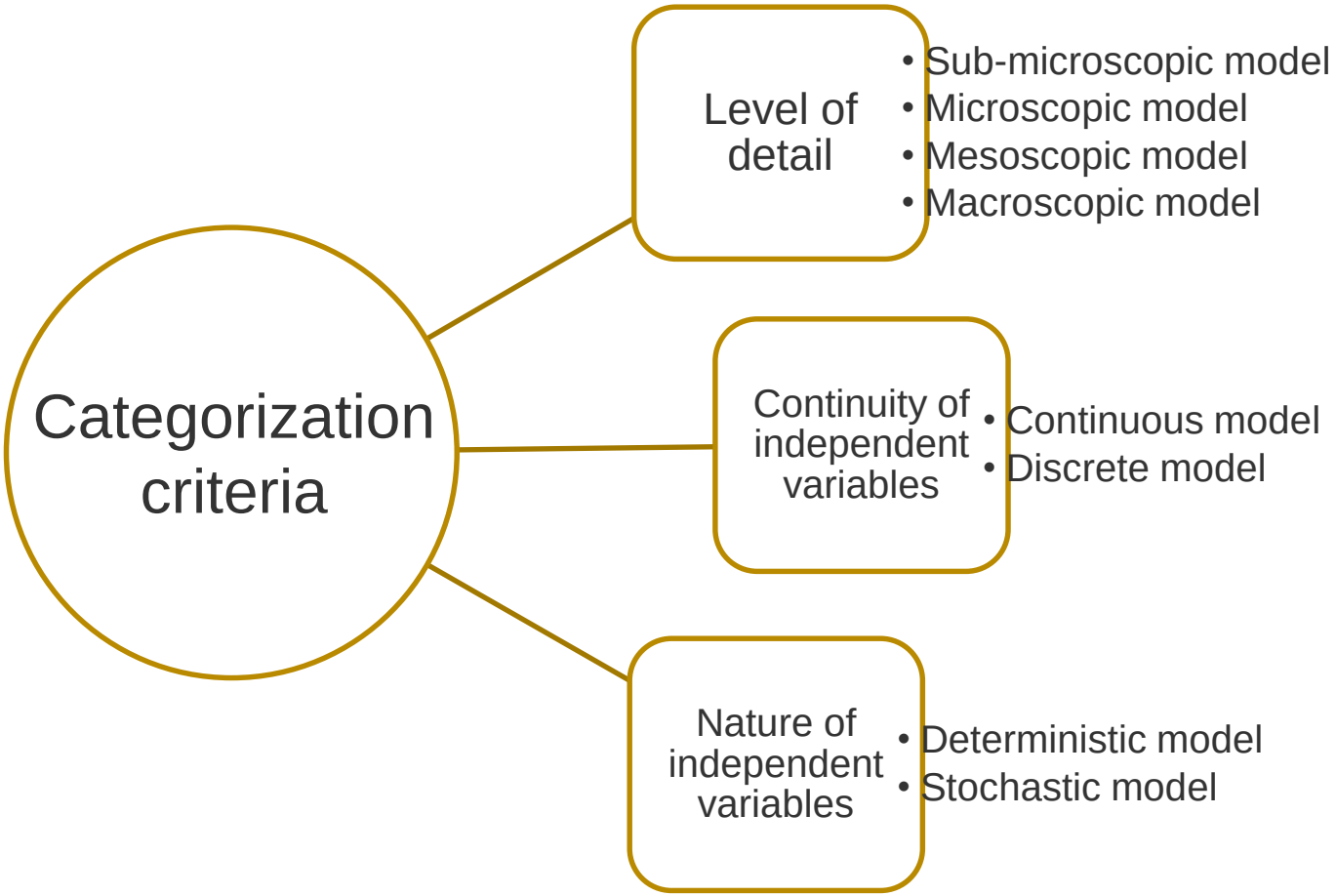
Content

- Literature review
  - Categorization of traffic flow models
  - Evolution of traffic flow models (macro-focused)
- METANET (target model)
  - Development history
  - Principles and key parameters
- Future plan

Literature review

– Categorization of traffic flow models

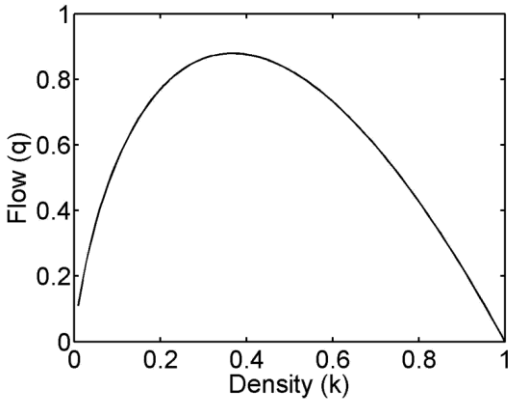


Literature review

-- macroscopic traffic flow models

- Core assumption

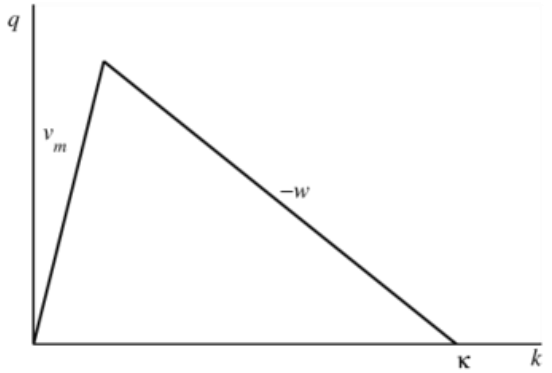
  Traffic flows as a whole and is compared to fluid streams.



- Two basic equations
  - Conservation equation -- $\frac{\partial \rho}{\partial t} + \frac{\partial q}{\partial x} = g(x,t)$

    -- $\frac{\partial}{\partial t}\int_{x_1}^{x_2} \rho(x,t)dx = q(x_1,t) - q(x_2,t) + g(x,t)$

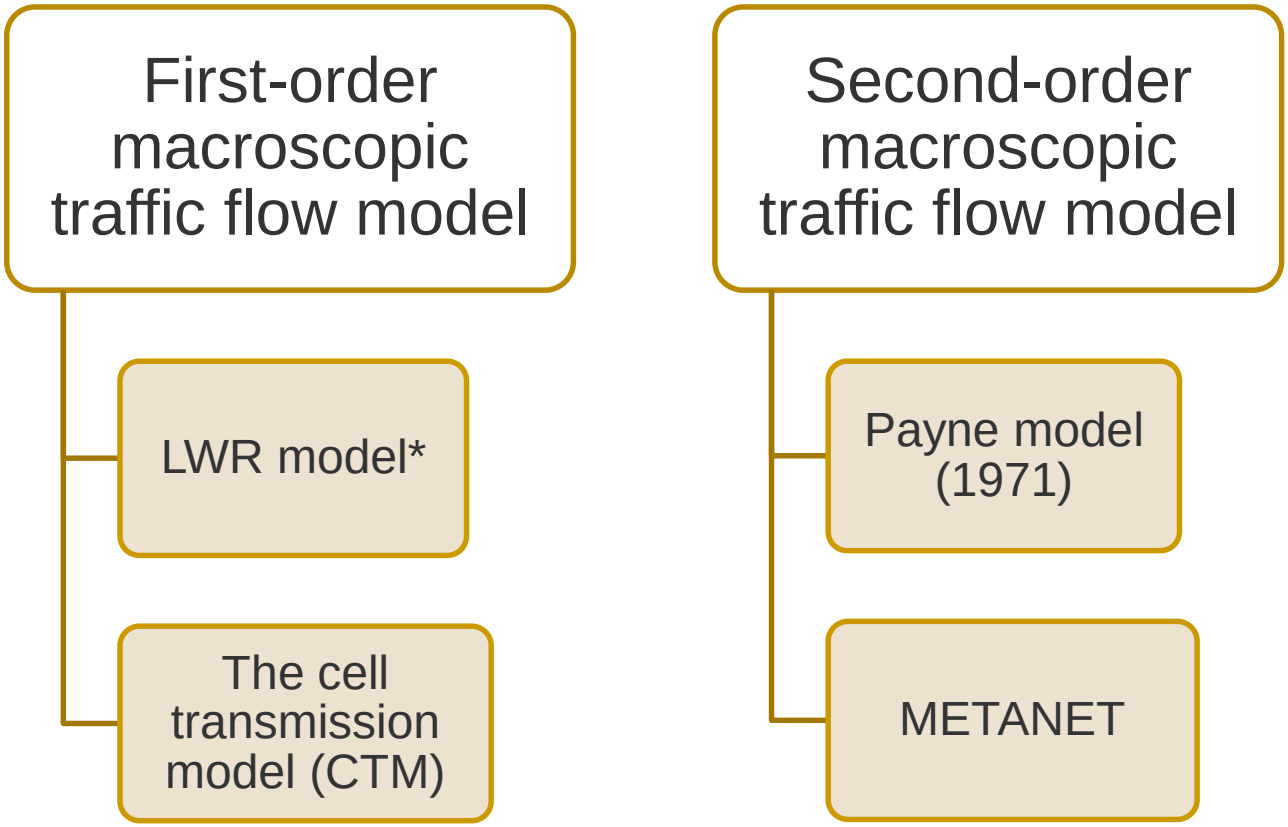
  - Traffic flow equation -- $q = v \times \rho$



Literature review

-- macroscopic traffic flow models

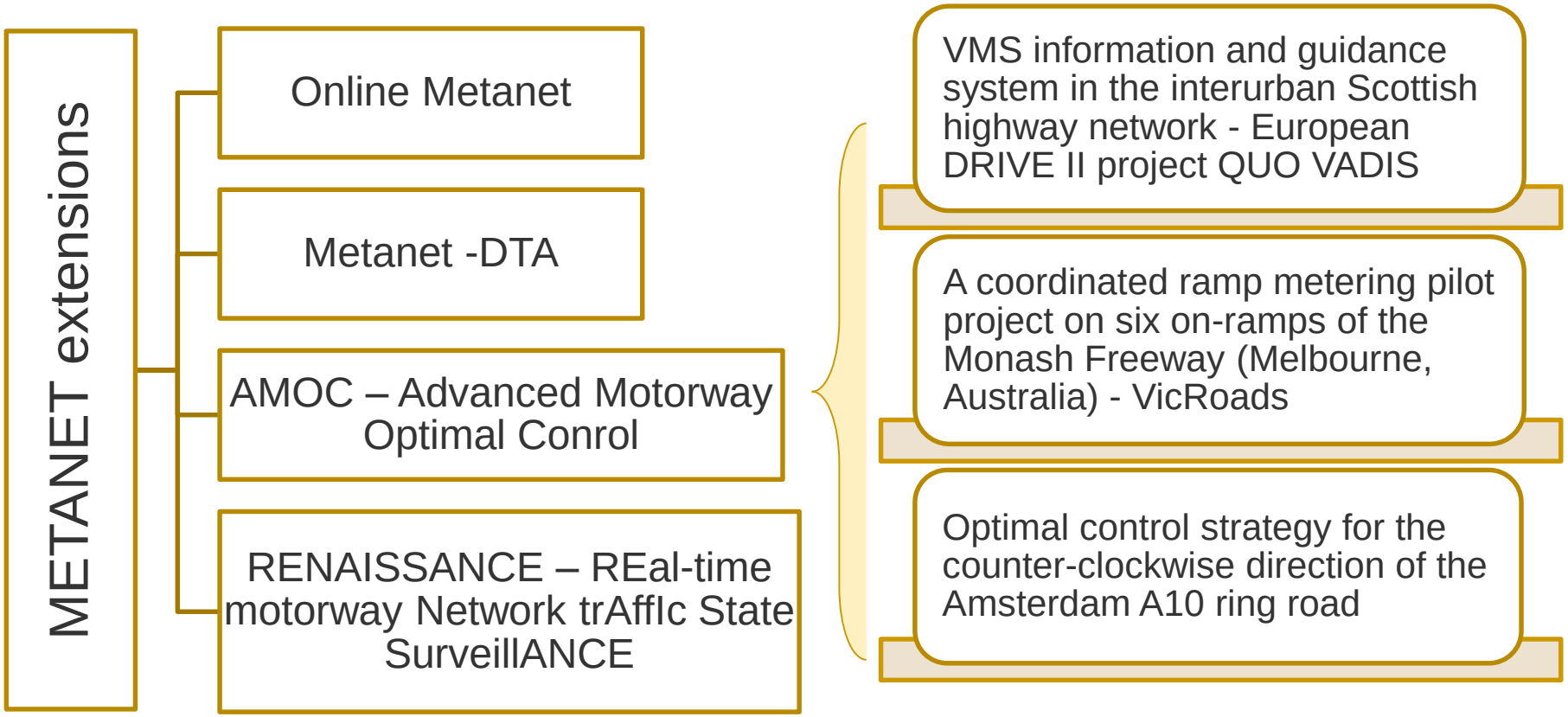
- Two categories



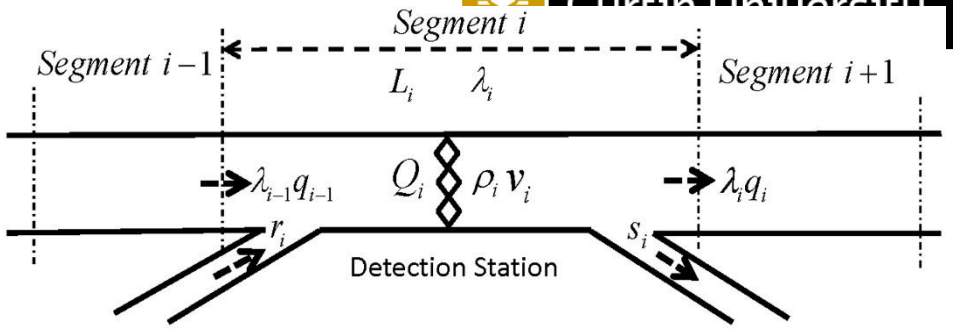
METANET

-- Evolutional history

- Features: Macroscopic; Deterministic; Second-order.



METANET



- Conservation equation:

$$\rho_i(k+1) = \rho_i(k) + \frac{T}{L_i\lambda_i}(\lambda_{i-1}q_{i-1}(k) - \lambda_i q_i(k) + r_i - s_i)$$

- Traffic flow equation: $q_i(k) = \rho_i(k)v_i(k)$
- Mean speed dynamics on the basis of static speed-density relationship:

$$v_i(k+1) = v_i(k) + \underbrace{\frac{T}{\tau}\{V[\rho_i(k)] - v_i(k)\}}_{\text{Relaxation}} + \underbrace{\frac{T}{L_i}v_i(k)[v_{i-1}(k) - v_i(k)]}_{\text{Convection}} + \underbrace{\frac{\nu T}{\tau L_i}\frac{\rho_{i+1}(k) - \rho_i(k)}{\rho_i(k) + \kappa}}_{\text{Anticipation}}$$

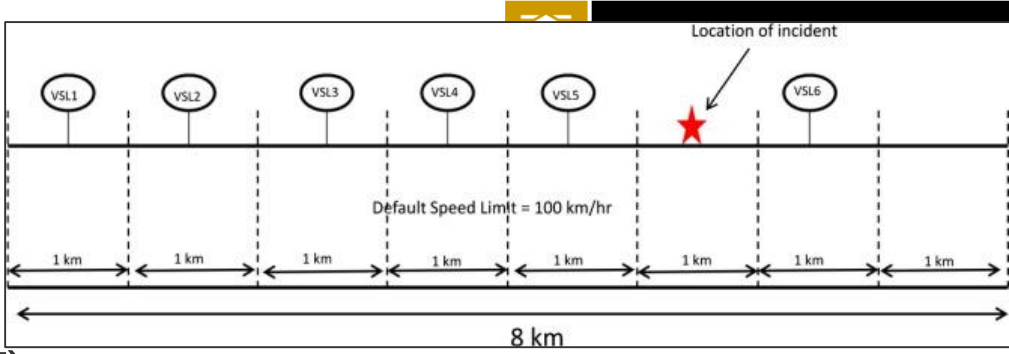
$$V[\rho_i(k)] = v_{free}exp\left[-\frac{1}{\alpha}\left(\frac{\rho_i(k)}{\rho_{cr}}\right)^{\alpha}\right]$$

- On- and off-ramps:

$$r_i(k) = min\left\{d_{ramp}(k) + \frac{\omega_{ramp}(k)}{T}, Q_{max,ramp}, Q_{max,ramp}\left(\frac{\rho_{jam,i} - \rho_i(k)}{\rho_{jam,i} - \rho_{cr}(k)}\right)\right\}$$

$$\omega_{ramp}(k+1) = \omega_{ramp}(k) + T\left[d_{ramp}(k) - r_i(k)\right]$$

METANET



During the time interval [kT, (k+1)T)

- Incorporation of Variable Speed Limit (VSL)

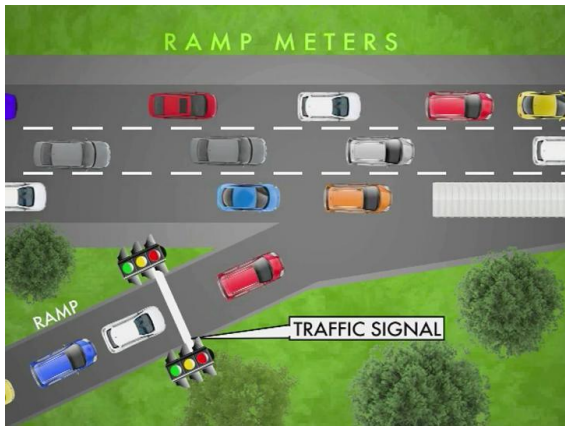
$$v_{free}^{*} = v_{free} \cdot b_i(k)$$

$$\rho_{cr}^{*} = \rho_{cr} \cdot A_i[1 - b_i(k)]$$

$$\alpha^{*} = \alpha \cdot [E_i - (E_i - 1) \cdot b_i\,(k)]$$

- Incorporation of Ramp Metering (RM)

$$r_i^{*}(k) = c(k) \cdot r_i(k)$$



$$= c(k) \cdot min\left\{d_{ramp}(k) + \frac{\omega_{ramp}(k)}{T}, Q_{max,ramp}, Q_{max,ramp}\left(\frac{\rho_{jam,i} - \rho_i(k)}{\rho_{jam,i} - \rho_{cr}(k)}\right)\right\}$$

Future plan

- Regression analysis → structure of FD
- Model calibration

Link-specific parameters	Global parameters
Free flow speed - v_{free}	Reaction time parameter - τ (hr)
Critical/ jam density - ρ_{cr}	Anticipation parameter - ν (km^2/hr)
Shape parameter of fundamental diagram (FD) - α	The positive constant - κ (vpkpl)
Mean μ and standard deviation σ of a stochastic flow influencing term $\xi_i^q \sim N(\mu, \sigma)$	
Mean μ and standard deviation σ of a stochastic speed influencing term $\xi_i^v \sim N(\mu, \sigma)$	

- Validation

Thanks for listening.

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