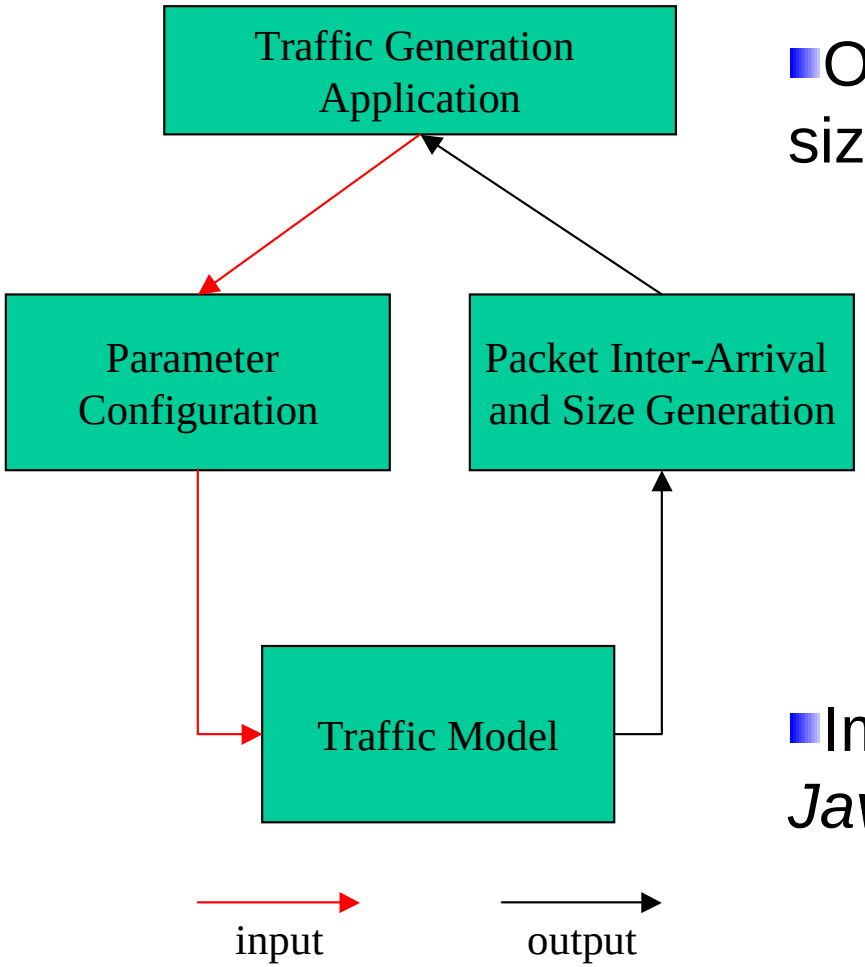


IMPLEMENTAION OF FSD Traffic Generation MODEL IN SIMULATOR

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Open-loop Traffic Generation

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- Open-loop generation of packet sizes and inter-arrivals
  - Input
    - Traffic load, e.g. packet rate, bit rate, or number of active connections
    - Packet size marginal distribution
  - Output
    - Packet sizes and inter-arrivals
  - Underlying model: FSD traffic model
- Implemented in simulators:*ns-2, JavaSim*

Fractional Sum-Difference Traffic Model

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$$z_u = \sqrt{1-\theta}\, s_u + \sqrt{\theta}\, n_u, 0 \le \theta \le 1$$

- n_u is Gaussian white noise with mean 0 and variance 1
- s_u is Gaussian fractional ARIMA time series

$$(I-B)^d s_u = \varepsilon_u + \varepsilon_{u-1}, 0 < d < 0.5$$

- ε_u is Gaussian white noise
- FSD Model Parameters
  - Fractional difference exponents $d_{(s)}$ and $d_{(i)}$ for packet size and packet inter-arrival
  - Variance ratios $\theta_{(s)}$ and $\theta_{(i)}$ for packet size and packet inter-arrival
- Z_u is transformed to packet size or packet inter-arrival according to their marginal distributions.

Marginal Distributions



Packet Inter-arrival Marginal Distribution

- Very well approximated by *Weibull* distribution
- *Weibull* random variable x with shape parameter λ and scale parameter α
  - $(x/\alpha)^{\lambda}$ is exponential
- Necessary parameters:
  - Shape parameter λ
  - Scale parameter α

Packet Size Marginal Distribution

- Discrete distribution
- Atoms at finite number k of values, such as 40, 576, and 1500 bytes
- Uniformly distributed elsewhere
- Necessary parameters:
  - Probabilities ϕ_1, ϕ_2, …, ϕ_k at atoms

Packet Inter-Arrival Model Parameters



- Fractional difference exponent $d_{(i)}$ for packet inter-arrival is constant and set to 0.41.
- Variance ratio $\theta_{(i)}$ for packet inter-arrival changes with the traffic load, i.e. active connection number γ.
  - $\theta_{(i)} = \theta_{(i)}(\gamma)$
- Weibull shape parameter λ, scale parameter α change with the traffic load, i.e. packet rate ρ and active connection number γ.
  - $\lambda = \lambda(\gamma)$
  - $\alpha = [\rho\Gamma(1+\lambda^{-1})]^{-1}$

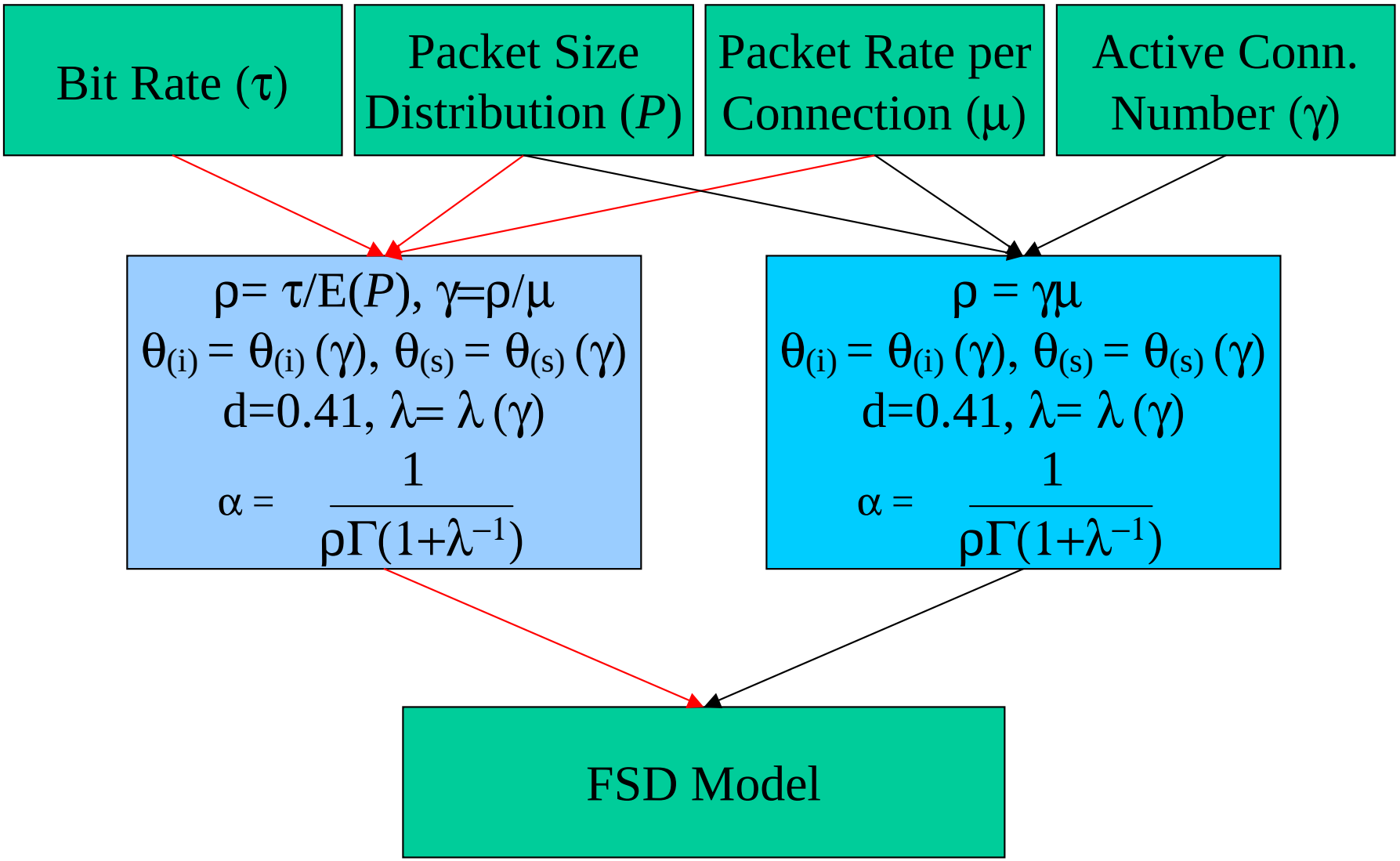
Packet Size Model Parameters



- Fractional difference exponent $d_{(s)}$ for packet size is constant and set to 0.41.
- Variance ratio $\theta_{(s)}$ for packet size changes with the traffic load, i.e. active connection number γ.
  - $\theta_{(s)} = \theta_{(s)}(\gamma)$
- Probabilities $\phi_1, \phi_2, \ldots, \phi_k$ at atoms change with link, but not appreciably with the load on the link.

FSD Parameter Setting in Simulator

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FSD Parameter Setting in Simulator

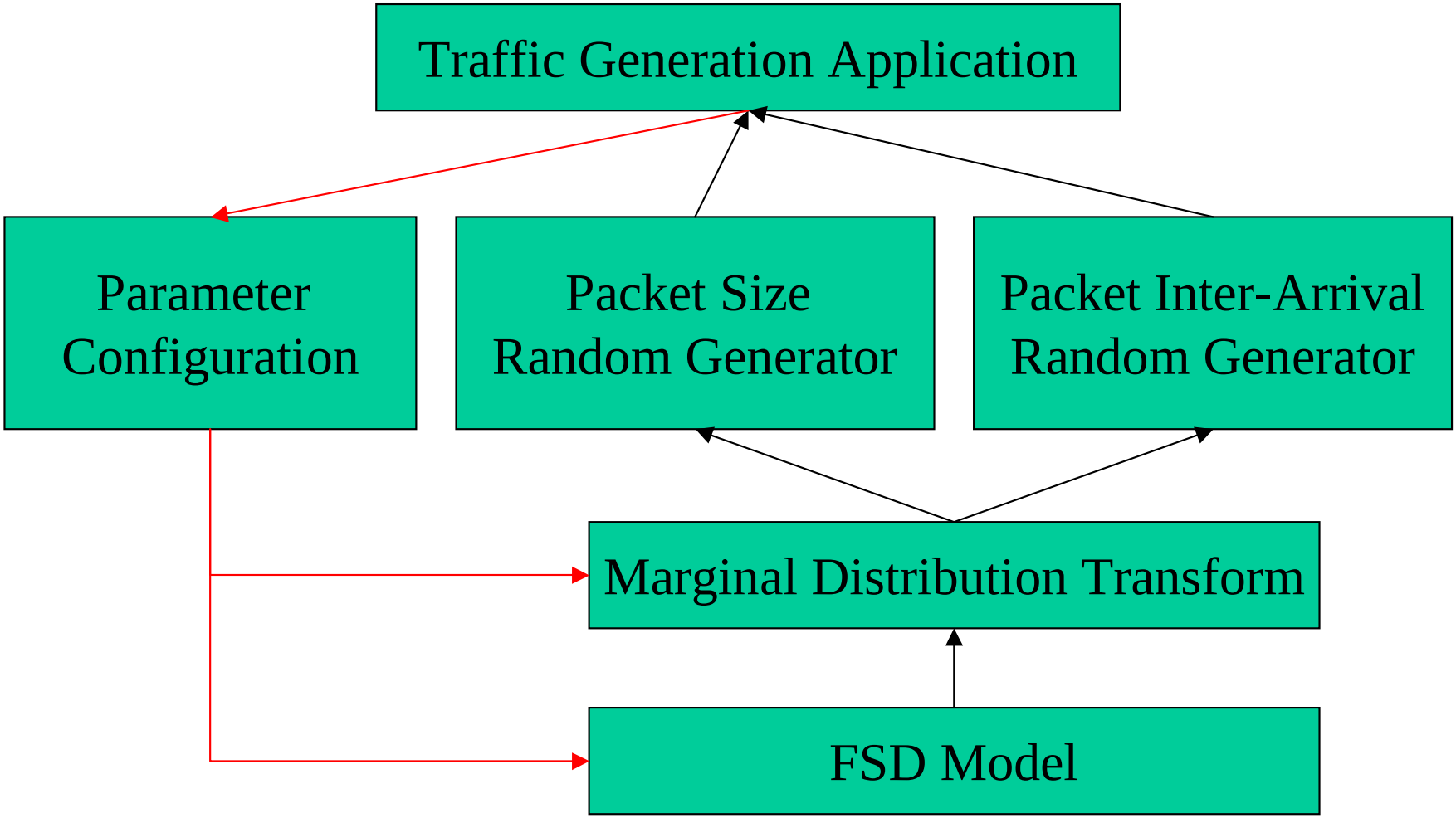
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- Traffic load, i.e. bit rate or active connection number must be specified.
- Packet rate per connection is optional. Default value is used if not provided.
- λ,α, $\theta_{(s)}$, and $\theta_{(i)}$ for packet size and inter-arrival
  - can be set directly or
  - calculated automatically according to traffic load.
- Probabilities ϕ_1, ϕ_2, …, ϕ_k can be set by a plain text file. Default marginal distribution is used if not provided.
  - Each line specifies packet size interval and its probability.
  - E.g. 40 40 0.5 means 50% packets have size of 40 bytes.

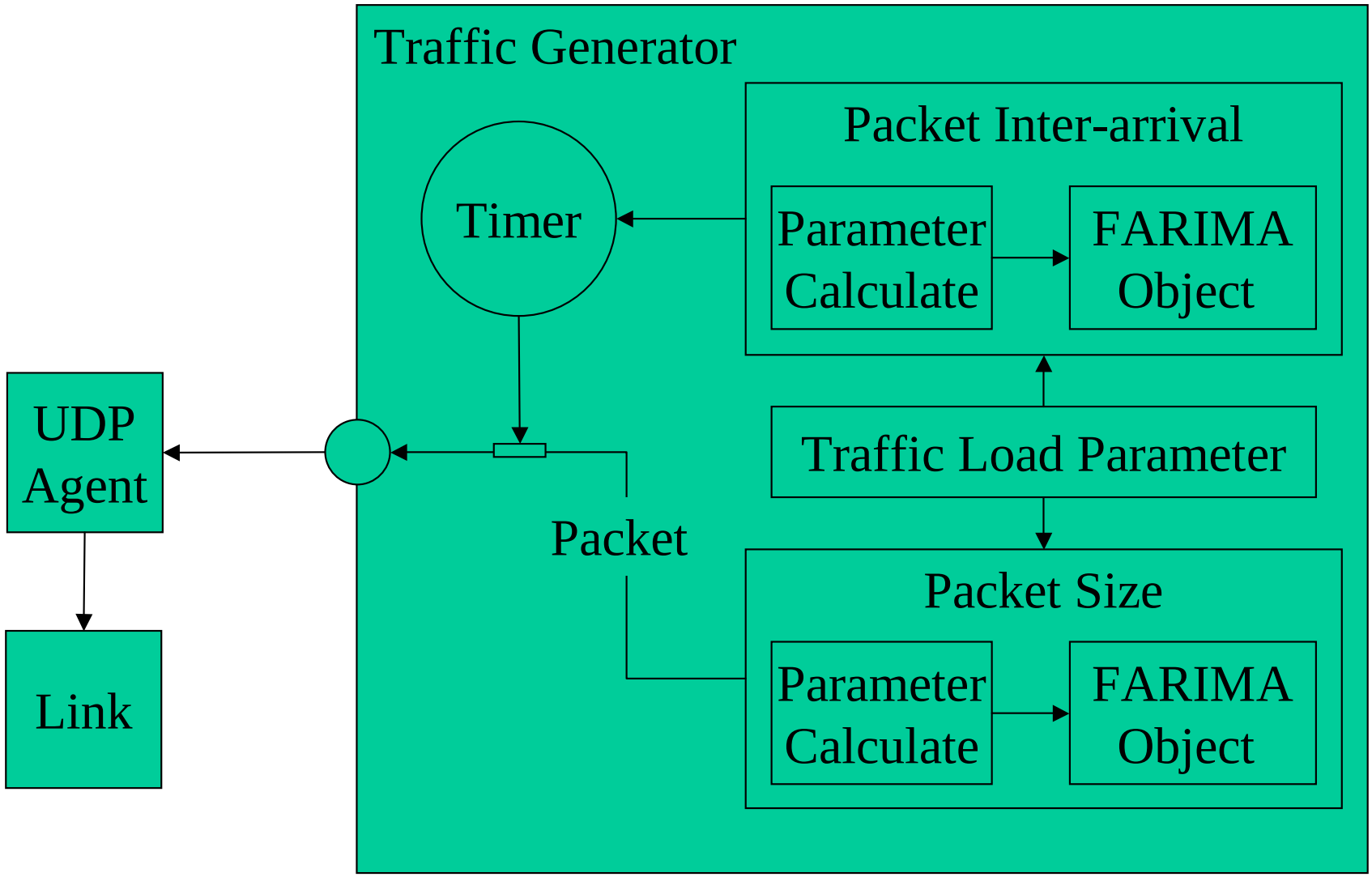
FSD Model Structure in Simulator

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Implementation in *ns-2*

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Structure of Traffic Generator