

# Distribution XML reference for Warteschlangensimulator

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This reference refers to version 5.7.0 of Warteschlangensimulator.  
Download address: <https://a-herzog.github.io/Warteschlangensimulator/>.

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When storing distribution settings to xml files the following xml tags will be used:

English version:

```
<ModelElementDistribution>distribution name (parameters)</ModelElementDistribution>
```

German version:

```
<ModellElementVerteilung>distribution name (parameters)</ModellElementVerteilung>
```

The English or German version will be used when storing xml data in Warteschlangensimulator. When reading xml files Warteschlangensimulator will always understand both versions.

In the following sections the possible values for "distribution name" and the corresponding "parameters" will be listed. Distribution parameters "mean" and "sd" correspond directly to the stochastic characteristics mean and standard deviation.

## Empirical data

**Empirical data** (point1;point2;point3;...)

**Empirische Daten** (point1;point2;point3;...)

The data points are interpreted as pdf values at equidistant points on the predefined range of the distribution.

## One point distribution

**One point distribution** (point)

**Ein-Punkt-Verteilung** (point)

Conversion between distribution parameters and stochastic characteristics

$$mean = point$$

$$sd = 0$$

## Uniform distribution

**Uniform distribution** (lower;upper)

**Gleichverteilung** (lower;upper)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned}
 mean &= (lower + upper)/2 \\
 sd &= (upper - lower)/\sqrt{12} \\
 lower &= mean - sd \cdot \sqrt{12}/2 \\
 upper &= mean + sd \cdot \sqrt{12}/2
 \end{aligned}$$

## Exponential distribution

Exponentialverteilung (mean)  
 Exponential distribution (mean)

Conversion between distribution parameters and stochastic characteristics

$$sd = mean$$

## Normal distribution

Normal distribution (mean;sd)  
 Normalverteilung (mean;sd)

## Lognormal distribution

Lognormal distribution (mean;sd)  
 Lognormalverteilung (mean;sd)

## Erlang distribution

Erlang distribution (shape;scale)  
 Erlang-Verteilung (shape;scale)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned}
 mean &= shape \cdot scale \\
 sd &= \sqrt{shape} \cdot scale \\
 scale &= sd^2 / mean \\
 shape &= mean^2 / sd^2
 \end{aligned}$$

## Gamma distribution

Gamma distribution (shape;scale)  
 Gamma-Verteilung (shape;scale)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned}
mean &= shape \cdot scale \\
sd &= \sqrt{shape} \cdot scale \\
scale &= sd^2 / mean \\
shape &= mean^2 / sd^2
\end{aligned}$$

## Beta distribution

**Beta distribution** (alpha;beta;lower;upper)

**Beta-Verteilung** (alpha;beta;lower;upper)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned}
mean &= alpha / (alpha + beta) \cdot (upper - lower) + lower \\
sd &= (upper - lower)^2 \cdot alpha \cdot beta / (alpha + beta)^2 / (1 + alpha + beta)
\end{aligned}$$

## Cauchy distribution

**Cauchy-Verteilung** (median;scale)

**Cauchy distribution** (median;scale)

## Weibull distribution

**Weibull distribution** (scaleInvers;shape)

**Weibull-Verteilung** (scaleInvers;shape)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned}
mean &= scale \cdot \Gamma(1 + (1/shape)) \\
sd &= scale \cdot \sqrt{\Gamma(1 + 2/shape) - (\Gamma(1 + 1/shape))^2}
\end{aligned}$$

## Chi distribution

**Chi distribution** (degreesOfFreedom)

**Chi-Verteilung** (degreesOfFreedom)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned}
mean &= \sqrt{2} \cdot \Gamma((degreesOfFreedom + 1)/2) / \Gamma(degreesOfFreedom/2) \\
sd &= \left[ (2 \cdot \Gamma(degreesOfFreedom/2) * \Gamma(1 + degreesOfFreedom/2) - \right. \\
&\quad \left. (\Gamma((degreesOfFreedom + 1)/2))^2) / \Gamma(degreesOfFreedom/2) \right]^{\frac{1}{2}}
\end{aligned}$$

## Chi<sup>2</sup> distribution

**Chi<sup>2</sup> distribution** (degreesOfFreedom)

**Chi<sup>2</sup>-Verteilung** (degreesOfFreedom)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned} \text{mean} &= \text{degreesOfFreedom} \\ \text{sd} &= \sqrt{2 \cdot \text{degreesOfFreedom}} \end{aligned}$$

## F distribution

**F distribution** (NumeratorDegreesOfFreedom;DenominatorDegreesOfFreedom)

**F-Verteilung** (NumeratorDegreesOfFreedom;DenominatorDegreesOfFreedom)

Conversion between distribution parameters and stochastic characteristics

(let  $m := \text{NumeratorDegreesOfFreedom}$  and  $n := \text{DenominatorDegreesOfFreedom}$ )

$$\begin{aligned} \text{mean} &= \frac{n}{n-2} \\ \text{sd} &= \sqrt{2 \cdot n^2 \cdot \frac{m+n-2}{m \cdot (n-2) \cdot (n-2) \cdot (n-4)}} \\ m &= \text{round} \left( 2 \cdot (2 \cdot \tilde{m})^2 \cdot \frac{2 \cdot \tilde{m} - 2}{\text{sd}^2 \cdot (2 \cdot \tilde{m} - 2)^2 \cdot (2 \cdot \tilde{m} - 4) - 2 \cdot (2 \cdot \tilde{m})^2} \right) \text{ with } \tilde{m} := \text{mean}/(\text{mean} - 1) \\ n &= \text{round}(2 \cdot \text{mean}/(\text{mean} - 1)) \end{aligned}$$

## Johnson SU distribution

**Johnson SU distribution** (gamma;xi;delta;lambda)

**Johnson-SU-Verteilung** (gamma;xi;delta;lambda)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned} \text{mean} &= xi - lambda \cdot \exp(1/(2 \cdot \text{delta}^2)) \cdot \sinh(\text{gamma}/\text{delta}) \\ \text{sd} &= \sqrt{\text{lambda}^2/2 \cdot (\exp(1/\text{delta}^2) - 1) \cdot (\exp(1/\text{delta}^2) * \cosh(2 * \text{gamma}/\text{delta}) + 1)} \end{aligned}$$

## Triangular distribution

**Triangular distribution** (lowerBound;mostLikelyX;upperBound)

**Dreiecksverteilung** (lowerBound;mostLikelyX;upperBound)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned} \text{mean} &= (\text{lowerBound} + \text{mostLikelyX} + \text{upperBound})/3 \\ \text{sd} &= \left[ (\text{lowerBound}^2 + \text{upperBound}^2 + \text{mostLikelyX}^2 - \text{lowerBound} \cdot \text{upperBound} - \right. \\ &\quad \left. \text{lowerBound} \cdot \text{mostLikelyX} - \text{upperBound} \cdot \text{mostLikelyX})/18 \right]^{\frac{1}{2}} \\ \text{lowerBound} &= \text{mean} - \text{sd} \cdot \sqrt{6} \\ \text{mostLikelyX} &= \text{mean} \\ \text{upperBound} &= \text{mean} + \text{sd} \cdot \sqrt{6} \end{aligned}$$

## Trapezoid distribution

Trapezoid distribution (a;b;c;d)

Trapezverteilung (a;b;c;d)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned}
 h &= \frac{2}{c + d - a - b} \\
 mean &= h \cdot 16 \left( \frac{d^3 - c^3}{d - c} - \frac{b^3 - a^3}{b - a} \right) \\
 sd &= \sqrt{h \cdot 112 \left( \frac{d^4 - c^4}{d - c} - \frac{b^4 - a^4}{b - a} \right) - mean^2}
 \end{aligned}$$

## Pert distribution

Pert distribution (lowerBound;mostLikelyX;upperBound)

Pert-Verteilung (lowerBound;mostLikelyX;upperBound)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned}
 mean &= (lowerBound + 4 \cdot mostLikelyX + upperBound) / 6 \\
 sd &= \left[ ((lowerBound + 4 \cdot mostLikelyX + upperBound) / 6 - lowerBound) \cdot \right. \\
 &\quad \left. (upperBound - (lowerBound + 4 \cdot mostLikelyX + upperBound) / 6) / 7 \right]^{\frac{1}{2}} \\
 lowerBound &= mean - sd \cdot \sqrt{7} \\
 mostLikelyX &= mean \\
 upperBound &= mean + sd \cdot \sqrt{7}
 \end{aligned}$$

## Laplace distribution

Laplace distribution (mean;b)

Laplace-Verteilung (mean;b)

Conversion between distribution parameters and stochastic characteristics

$$sd = b \cdot \sqrt{2}$$

## Pareto distribution

Pareto distribution (xmin;alpha)

Pareto-Verteilung (xmin;alpha)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned}
 mean &= alpha \cdot xmin / (alpha - 1) \\
 sd &= xmin^2 \cdot alpha / (alpha - 1)^2 / (alpha - 2) \\
 alpha &= mean / (mean - xmin)
 \end{aligned}$$

## Logistic distribution

Logistic distribution (mean;s)  
 Logistische Verteilung (mean;s)

Conversion between distribution parameters and stochastic characteristics

$$sd = s \cdot \pi / \sqrt{3}$$

## Inverse gaussian distribution

Inverse gaussian distribution (lambda;mu)  
 Inverse Gauß-Verteilung (lambda;mu)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned} mean &= mu \\ sd &= mu \cdot \sqrt{mu/lambda} \\ lambda &= mean^3 / sd^2 \end{aligned}$$

## Rayleigh distribution

Rayleigh distribution (mean)  
 Rayleigh-Verteilung (mean)

Conversion between distribution parameters and stochastic characteristics

$$sd = \sqrt{(4 - \pi)/2} \cdot \sqrt{2/\pi} \cdot mean$$

## Log-logistic distribution

Log-logistic distribution (alpha;beta)  
 Log-Logistische Verteilung (alpha;beta)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned} mean &= alpha \cdot \pi / beta / \sin(\pi/beta) \\ sd &= alpha \cdot \sqrt{2 \cdot \pi / beta / \sin(2 \cdot \pi / beta) - \pi^2 / beta^2 / \sin(\pi/beta)} \end{aligned}$$

## Power distribution

Power distribution (a;b;c)  
 Potenzverteilung (a;b;c)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned} mean &= a + (b - a) \cdot c / (c + 1) \\ sd &= (b - a) / (c + 1) \cdot \sqrt{c / (c + 2)} \end{aligned}$$

## Gumbel distribution

Gumbel distribution (mean;sd)  
Gumbel-Verteilung (mean;sd)

## Fatigue life distribution

Fatigue life distribution (mu;beta;gamma)  
Fatigue-Life-Verteilung (mu;beta;gamma)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned} mean &= mu + beta \cdot (1 + gamma \cdot gamma/2) \\ sd &= beta \cdot gamma \cdot \sqrt{1 + 5 \cdot gamma^2/4} \end{aligned}$$

## Frechet distribution

Frechet distribution (delta;beta;alpha)  
Frechet-Verteilung (delta;beta;alpha)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned} mean &= delta + beta \cdot gamma(1 - 1/alpha) \\ sd &= beta \cdot \sqrt{gamma(1 - 2/alpha) - gamma(1 - 1/alpha)^2} \end{aligned}$$

## Hyperbolic secant distribution

Hyperbolic secant distribution (mean;sd)  
Hyperbolische Sekanten-Verteilung (mean;sd)

## Left sawtooth distribution

Left sawtooth distribution (a;b)  
Linke Sägezahnverteilung (a;b) Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned} mean &= (2 \cdot a + b)/2 \\ sd &= (b - a)^2/18 \end{aligned}$$

## Right sawtooth distribution

Right sawtooth distribution (a;b)  
Rechte Sägezahnverteilung (a;b) Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned} \text{mean} &= (a + 2 \cdot b)/2 \\ \text{sd} &= (b - a)^2/18 \end{aligned}$$

## Levy distribution

Levy distribution (mu;c)  
Levy-Verteilung (mu;c)

## Maxwell Boltzmann distribution

Maxwell Boltzmann distribution (a)  
Maxwell-Boltzmann-Verteilung (a)

$$\begin{aligned} \text{mean} &= 2 \cdot a \sqrt{\frac{2}{\pi}} \\ \text{sd} &= \sqrt{\frac{a^2(3\pi - 8)}{\pi}} \\ \text{modus} &= a\sqrt{2} \\ a &= \frac{\text{mean}}{2} \cdot \sqrt{\frac{\pi}{2}} \end{aligned}$$

## Student t-distribution

Student t-distribution (mu;nu)  
Studentische t-Verteilung (mu;nu) Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned} \text{mean} &= \mu \\ \text{sd} &= \sqrt{\frac{\nu}{\nu - 2}} \quad \text{for } \nu > 2 \end{aligned}$$

## Half normal distribution

Halbe Normalverteilung (mean)  
Half normal distribution (mean)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned} \text{mean} &= \frac{1}{\theta} \\ \text{sd} &= \frac{\pi - 2}{2\theta^2} \end{aligned}$$



## U-quadratic distribution

U-quadratische Verteilung (a;b)

U-quadratic distribution (a;b)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned} mean &= \frac{a+b}{2} \\ sd &= \frac{3}{20} \cdot (b-a)^2 \\ a &= mean - \frac{\sqrt{sd^2 \cdot \frac{20}{3}}}{2} \\ b &= mean + \frac{\sqrt{sd^2 \cdot \frac{20}{3}}}{2} \end{aligned}$$

## Reciprocal distribution

Reziproke Verteilung (a;b)

Reciprocal distribution (a;b)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned} mean &= \frac{b-a}{\log\left(\frac{b}{a}\right)} \\ sd &= \sqrt{\frac{b^2 - a^2}{\log\left(\frac{b}{a}\right)} - \left(\frac{b-a}{\log\left(\frac{b}{a}\right)}\right)^2} \end{aligned}$$

## Kumaraswamy distribution

Kumaraswamy-Verteilung (a;b;c;d)

Kumaraswamy distribution (a;b;c;d)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned} mean_{\text{unscaled}} &= \frac{b\Gamma\left(1 + \frac{1}{a}\right)\Gamma(b)}{\Gamma\left(1 + \frac{1}{a} + b\right)} \\ sd_{\text{unscaled}} &= \sqrt{\frac{b\Gamma\left(1 + \frac{2}{a}\right)\Gamma(b)}{\Gamma\left(1 + \frac{2}{a} + b\right)} - mean_{\text{unscaled}}^2} \\ mean &= mean_{\text{unscaled}} \cdot (d-c) + c \\ sd &= sd_{\text{unscaled}} \cdot (d-c) + c \end{aligned}$$

## Irwin-Hall distribution

Irwin-Hall-Verteilung (n)  
Irwin-Hall distribution (n)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned} \text{mean} &= \frac{n}{2} \\ \text{sd} &= \sqrt{\frac{n}{12}} \end{aligned}$$

## Sine distribution

Sinus-Verteilung (a;b)  
sine distribution (a;b)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned} \text{mean} &= \frac{a+b}{2} \\ \text{sd} &= \sqrt{\frac{1}{4} - \frac{2}{\pi^2}} \cdot (b-a)^2 \end{aligned}$$

## Arcsine distribution

Arcus Sinus-Verteilung (a;b)  
arcsine distribution (a;b)

Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned} \text{mean} &= \frac{a+b}{2} \\ \text{sd} &= \frac{1}{8} \cdot (b-a)^2 \end{aligned}$$

## Hypergeometric distribution

Hypergeometric distribution (N;K;n) Hypergeometrische Verteilung (N;K;n) Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned} \text{mean} &= \frac{n \cdot K}{N} \\ \text{sd} &= \sqrt{\frac{n \cdot K}{N} \cdot \left(1 - \frac{K}{N}\right) \cdot \frac{N-n}{N-1}} \end{aligned}$$

## Binomial distribution

Binomial distribution (n;p) Binomialverteilung (n;p) Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned}
 mean &= n \cdot p \\
 sd &= \sqrt{n \cdot p \cdot (1 - p)} \\
 n &= \frac{mean}{p} \\
 p &= 1 - \frac{sd^2}{mean}
 \end{aligned}$$

## Poisson distribution

Poisson distribution (lambda) Poisson-Verteilung (lambda)

$$\begin{aligned}
 mean &= \lambda \\
 sd &= \lambda
 \end{aligned}$$

## Negative binomial distribution

Negative binomial distribution (n;r) Negative Binomialverteilung (n;r)

$$\begin{aligned}
 mean &= r(1 - p)/p \\
 sd &= \sqrt{\frac{r(1 - p)}{p^2}} \\
 p &= \frac{mean}{sd^2} \\
 r &= \frac{mean \cdot p}{1 - p}
 \end{aligned}$$

## Negative Hypergeometric distribution

Negative hypergeometric distribution (N;K;n) Negative hypergeometrische Verteilung (N;K;n)  
Conversion between distribution parameters and stochastic characteristics

$$\begin{aligned}
 mean &= n \cdot \frac{N + 1}{R + 1} \\
 sd &= \sqrt{n \cdot \frac{(R + 1 - n)(N - R)(N + 1)}{(R + 1)^2(R + 2)}}
 \end{aligned}$$

## Zeta distribution

Zeta distribution (s) Zeta-Verteilung (s)

$$\begin{aligned}
 mean &= \frac{\zeta(s - 1)}{\zeta(s)} \\
 sd &= \sqrt{\frac{\zeta(s)\zeta(s - 2) - \zeta(s - 1)^2}{\zeta(s)^2}}
 \end{aligned}$$

## Discrete uniform distribution

Discrete uniform distribution (a;b) Diskrete Gleichverteilung (n;r)

$$\begin{aligned}
 mean &= \frac{a+b}{2} \\
 sd &= \frac{(b-a+1)^2-1}{12} \\
 b &= \frac{\sqrt{(12 \cdot sd^2 + 1)}}{2} + mean - \frac{1}{2} \\
 a &= 2 \cdot mean - b
 \end{aligned}$$