Tubes Pemstok

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```
# install if needed
# install.packages(c("readxl", "queueing", "fitdistrplus", "ggplot2", "dplyr"))
# install.packages("hms")
library(readxl)
```

```
## Warning: package 'readxl' was built under R version 4.5.2
```

```
library(queueing)
```

```
## Warning: package 'queueing' was built under R version 4.5.2
```

```
library(fitdistrplus)
```

```
## Warning: package 'fitdistrplus' was built under R version 4.5.2
```

```
## Loading required package: MASS
```

```
## Loading required package: survival
```

```
library(ggplot2)
```

```
## Warning: package 'ggplot2' was built under R version 4.5.2
```

```
library(dplyr)
```

```
## Warning: package 'dplyr' was built under R version 4.5.2
```

```
##
## Attaching package: 'dplyr'
```

```
## The following object is masked from 'package:MASS':
##
##     select
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(hms)
```

```
## Warning: package 'hms' was built under R version 4.5.2
```

```
df <- read_excel("C:/Users/sdthi/Downloads/Data Pemstok (1).xlsx")
```

```
df$Datang   <- as_hms(as.POSIXct(df$Datang,   format="%H:%M:%S"))
df$Dilayani <- as_hms(as.POSIXct(df$Dilayani, format="%H:%M:%S"))
df$Pergi    <- as_hms(as.POSIXct(df$Pergi,    format="%H:%M:%S"))
```

```
df
```

```
## # A tibble: 349 × 3
##    Datang   Dilayani Pergi
##    <time>   <time>   <time>
##  1 08:00:10 08:00:27 08:01:11
##  2 08:00:45 08:01:19 08:02:07
##  3 08:00:57 08:02:07 08:02:57
##  4 08:01:07 08:03:03 08:04:02
##  5 08:02:00 08:04:14 08:05:15
##  6 08:02:45 08:05:17 08:05:57
##  7 08:04:14 08:06:00 08:07:03
##  8 08:04:19 08:07:05 08:07:53
##  9 08:04:40 08:08:02 08:08:52
## 10 08:05:22 08:08:55 08:10:45
## # ℹ 339 more rows
```

```
df <- df %>% arrange(Datang)
df$interarrival <- c(NA, diff(df$Datang))
df$interarrival <- df$interarrival / 60
```

```
df$service <- as.numeric(df$Pergi - df$Dilayani)
df$service <- df$service / 60
```

```
head(df)
```

```
## # A tibble: 6 × 5
##   Datang   Dilayani Pergi    interarrival service
##   <time>   <time>   <time>          <dbl>   <dbl>
## 1 08:00:10 08:00:27 08:01:11       NA       0.733
## 2 08:00:45 08:01:19 08:02:07        0.583   0.8
## 3 08:00:57 08:02:07 08:02:57        0.2     0.833
## 4 08:01:07 08:03:03 08:04:02        0.167   0.983
## 5 08:02:00 08:04:14 08:05:15        0.883   1.02
## 6 08:02:45 08:05:17 08:05:57        0.75    0.667
```

```
View(df)
```

```
summary(df)
```

```
##      Datang                    Dilayani                    Pergi
##  Min.   :08:00:10.000000   Min.   :08:00:27.000000   Min.   :08:01:11.00000
##  1st Qu.:09:33:45.000000   1st Qu.:09:41:37.000000   1st Qu.:09:42:24.00000
##  Median :12:15:03.000000   Median :12:15:03.000000   Median :12:15:50.00000
##  Mean   :12:28:34.882522   Mean   :12:31:37.744986   Mean   :12:32:38.39255
##  3rd Qu.:15:17:03.000000   3rd Qu.:15:23:28.000000   3rd Qu.:15:24:03.00000
##  Max.   :17:58:51.000000   Max.   :18:06:15.000000   Max.   :18:07:10.00000
##
##   interarrival       service
##  Min.   : 0.000   Min.   :0.2500
##  1st Qu.: 0.400   1st Qu.:0.7667
##  Median : 1.092   Median :0.9833
##  Mean   : 1.720   Mean   :1.0108
##  3rd Qu.: 2.337   3rd Qu.:1.2167
##  Max.   :12.483   Max.   :2.0667
##  NA's   :1
```

```
library(psych)
```

```
## Warning: package 'psych' was built under R version 4.5.2
```

```
##
## Attaching package: 'psych'
```

```
## The following objects are masked from 'package:ggplot2':
##
##     %+%, alpha
```

```
describe(df)
```

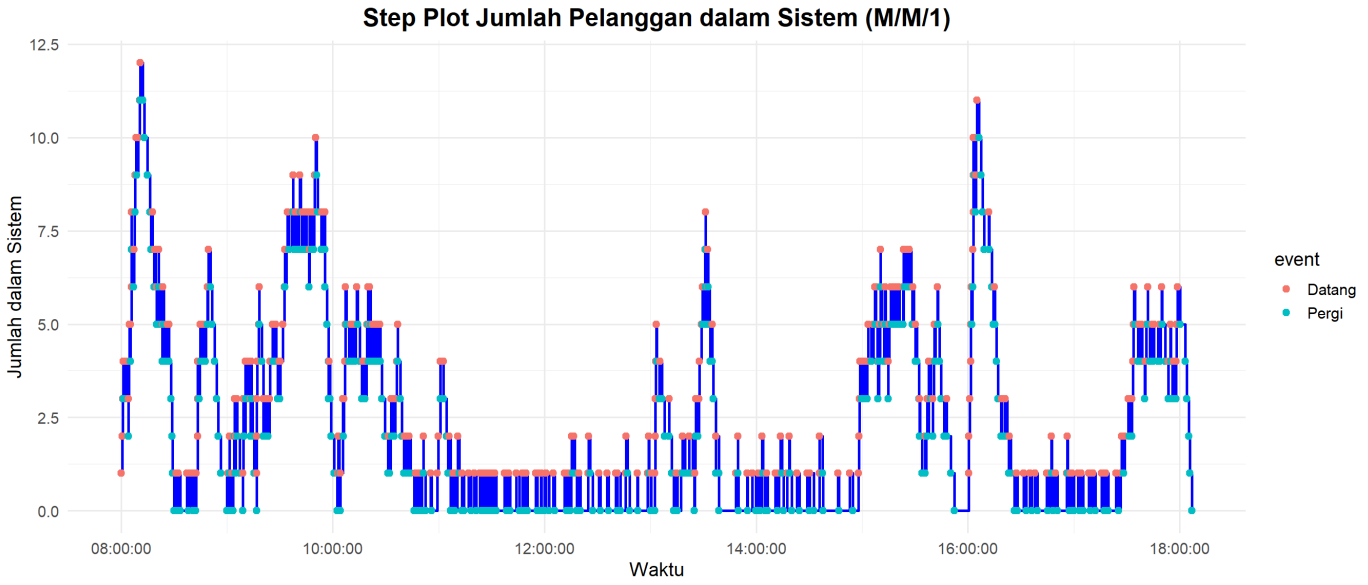
```
## Warning in FUN(newX[, i], ...): no non-missing arguments to min; returning Inf
```

```
## Warning in FUN(newX[, i], ...): no non-missing arguments to min; returning Inf
## Warning in FUN(newX[, i], ...): no non-missing arguments to min; returning Inf
```

```
## Warning in FUN(newX[, i], ...): no non-missing arguments to max; returning -Inf
## Warning in FUN(newX[, i], ...): no non-missing arguments to max; returning -Inf
## Warning in FUN(newX[, i], ...): no non-missing arguments to max; returning -Inf
```

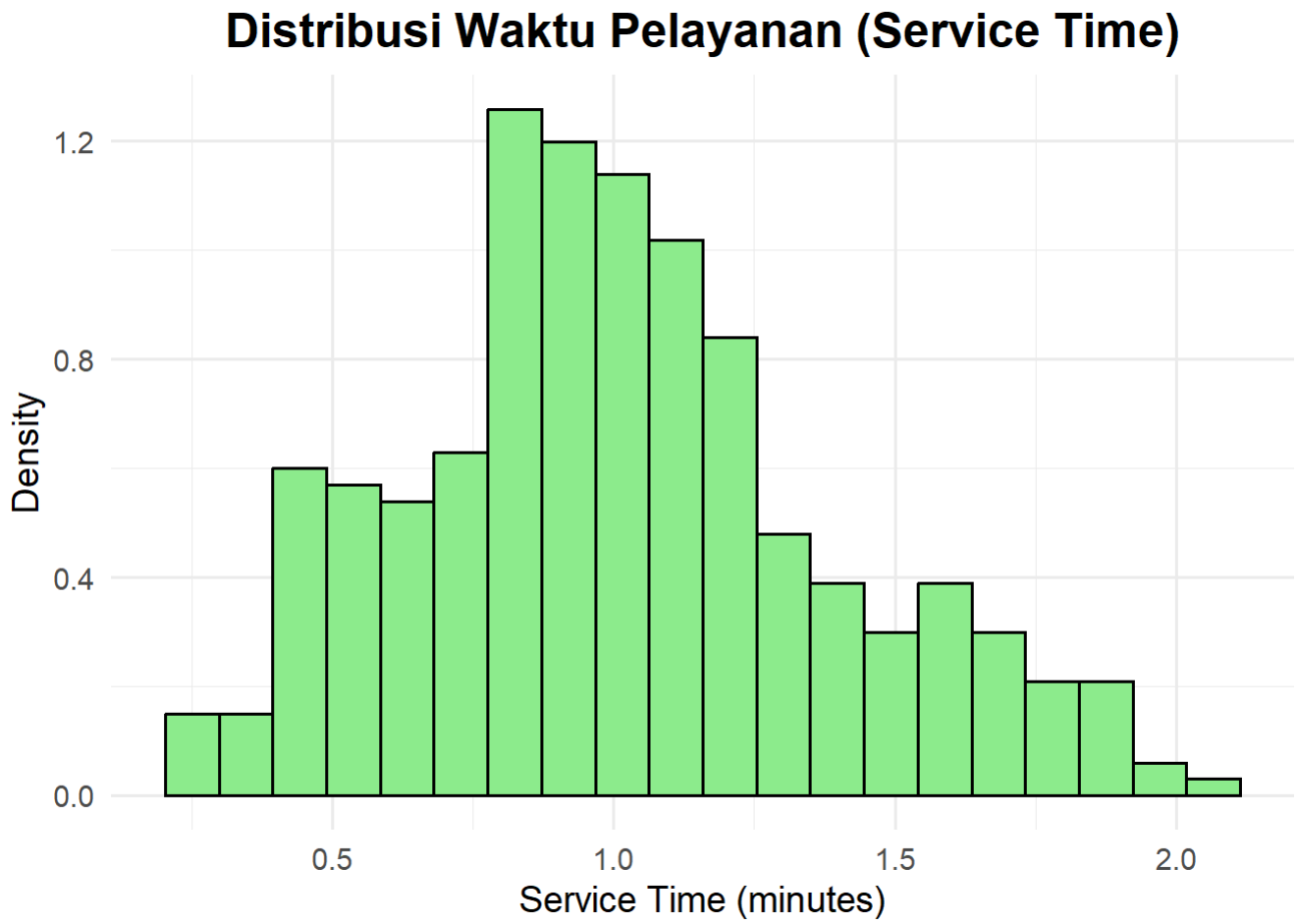
```
##              vars   n mean   sd median trimmed  mad  min   max range skew
## Datang          1 349  NaN   NA     NA     NaN   NA  Inf  -Inf  -Inf   NA
## Dilayani        2 349  NaN   NA     NA     NaN   NA  Inf  -Inf  -Inf   NA
## Pergi           3 349  NaN   NA     NA     NaN   NA  Inf  -Inf  -Inf   NA
## interarrival    4 348 1.72 1.89   1.09    1.38 1.20 0.00 12.48 12.48 2.20
## service         5 349 1.01 0.38   0.98    0.99 0.32 0.25  2.07  1.82 0.38
##              kurtosis   se
## Datang             NA   NA
## Dilayani           NA   NA
## Pergi              NA   NA
## interarrival     6.70 0.10
## service         -0.22 0.02
```

```
events <- data.frame(
  time = c(df$Datang, df$Pergi),
  change = c(rep(1, nrow(df)), rep(-1, nrow(df)))
)

# Urutkan berdasarkan waktu
events <- events %>% arrange(time)

# Tambahkan label event
events$event <- ifelse(events$change == 1, "Datang", "Pergi")

# Hitung jumlah dalam sistem N(t)
events$N <- cumsum(events$change)

# Plot
ggplot(events, aes(x = time, y = N)) +
  geom_step(linewidth = 1, color = "blue") +
  geom_point(aes(color = event), size = 2) +
  labs(
    title = "Step Plot Jumlah Pelanggan dalam Sistem (M/M/1)",
    x = "Waktu",
    y = "Jumlah dalam Sistem"
  ) +
  theme_minimal(base_size = 14)+
  theme(
    plot.title = element_text(hjust = 0.5, size = 18, face = "bold")
  )
```

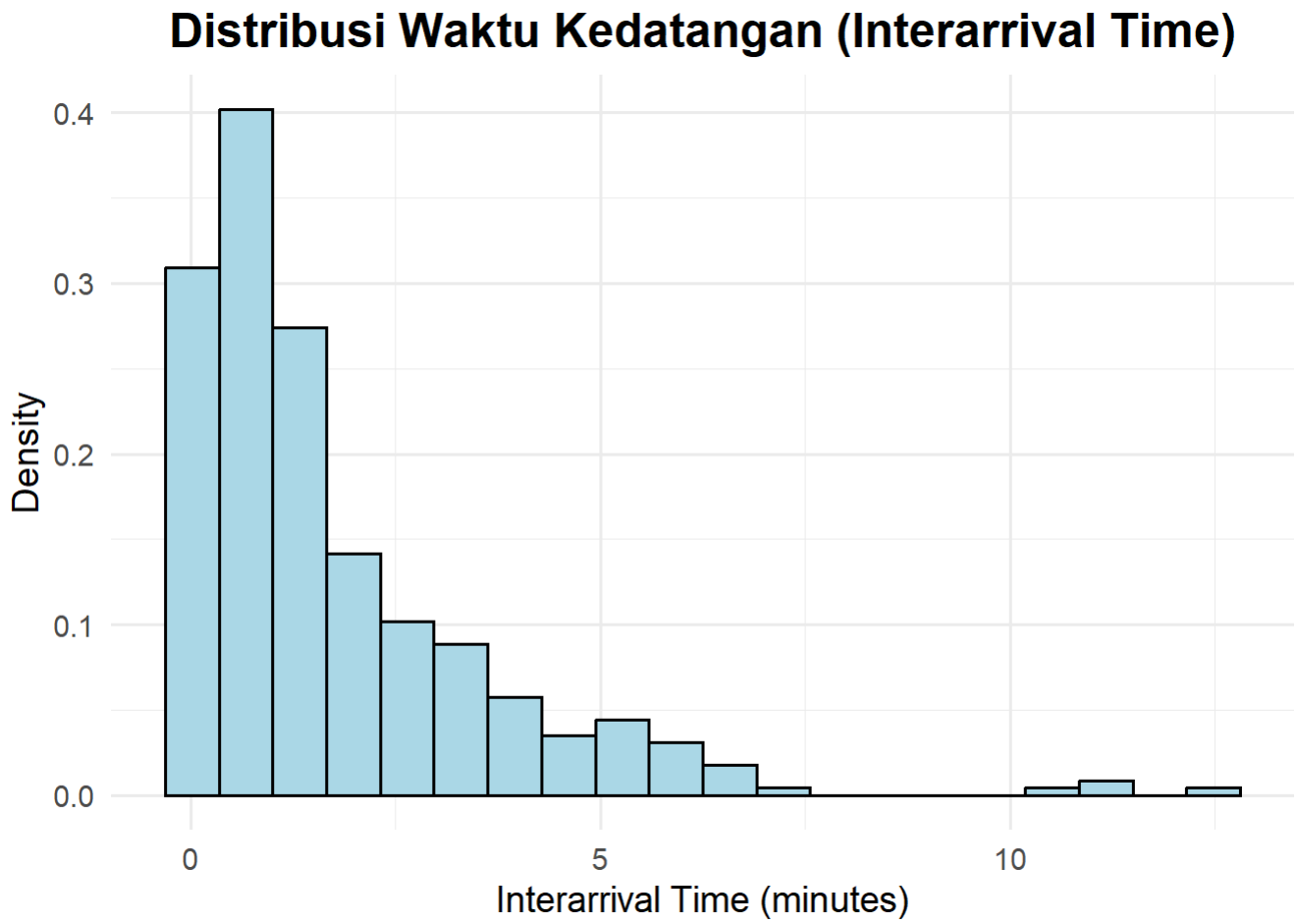



```
ggplot(df, aes(x = service)) +
  geom_histogram(aes(y = ..density..), bins = 20, fill = "lightgreen", color = "black") +
  labs(title = "Distribusi Waktu Pelayanan (Service Time)",
       x = "Service Time (minutes)", y = "Density")+
  theme_minimal(base_size = 14) +
  theme(
    plot.title = element_text(hjust = 0.5, size = 18, face = "bold")
  )
```

```
## Warning: The dot-dot notation (`..density..`) was deprecated in ggplot2 3.4.0.
## ℹ Please use `after_stat(density)` instead.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```




```
ggplot(df %>% filter(interarrival > 0), aes(x = interarrival)) +
  geom_histogram(aes(y = ..density..), bins = 20, fill = "lightblue", color = "black") +
  labs(title = "Distribusi Waktu Kedatangan (Interarrival Time)",
       x = "Interarrival Time (minutes)", y = "Density")+
  theme_minimal(base_size = 14) +
  theme(
    plot.title = element_text(hjust = 0.5, size = 18, face = "bold")
  )
```




```
library(MASS)
ia <- df$interarrival
ia <- df$interarrival[!is.na(ia) & ia > 0]
fit <- fitdist(ia, "exp")

# goodness of fit test
ks.test(df$interarrival, "pexp", fit$estimate)
```

```
## Warning in ks.test.default(df$interarrival, "pexp", fit$estimate): ties should
## not be present for the one-sample Kolmogorov-Smirnov test
```

```
##
##  Asymptotic one-sample Kolmogorov-Smirnov test
##
## data:  df$interarrival
## D = 0.053489, p-value = 0.2724
## alternative hypothesis: two-sided
```

```
fit2 <- fitdistr(df$service, "exponential")
ks.test(df$service, "pexp", fit2$estimate)
```

```
## Warning in ks.test.default(df$service, "pexp", fit2$estimate): ties should not
## be present for the one-sample Kolmogorov-Smirnov test
```

```
##
##  Asymptotic one-sample Kolmogorov-Smirnov test
##
## data:  df$service
## D = 0.31343, p-value < 2.2e-16
## alternative hypothesis: two-sided
```

```
lambda <- 1 / mean(df$interarrival, na.rm=TRUE)
mu     <- 1 / mean(df$service, na.rm=TRUE)
fit <- fitdist(ia, "exp")   # untuk lambda
fit_sv <- fitdist(df$service, "exp")
cat("Rata-rata waktu kedatangan:", mean(df$interarrival, na.rm=TRUE), "menit\n")
```

```
## Rata-rata waktu kedatangan: 1.720354 menit
```

```
cat("Rata-rata waktu pelayanan:", mean(df$service, na.rm=TRUE), "menit\n")
```

```
## Rata-rata waktu pelayanan: 1.010793 menit
```

```
lambda_hat <- fit$estimate  # λ (rate kedatangan)
mu_hat     <- fit_sv$estimate  # μ (rate pelayanan)
lambda; mu
```

```
## [1] 0.5812756
```

```
## [1] 0.9893225
```

```
cat("Rata-rata tingkat Kedatangan (Lambda):", round(lambda, 2), "orang/menit\n")
```

```
## Rata-rata tingkat Kedatangan (Lambda): 0.58 orang/menit
```

```
cat("Kapasitas Pelayanan (Mu)     :", round(mu, 2), "orang/menit\n")
```

```
## Kapasitas Pelayanan (Mu)     : 0.99 orang/menit
```

```
cat("Estimasi λ (arrival rate)  =", lambda_hat, "\n")
```

```
## Estimasi λ (arrival rate)  = 0.5762646
```

```
cat("Estimasi μ (service rate)  =", mu_hat, "\n")
```

```
## Estimasi μ (service rate)  = 0.9893225
```

```
rho <- lambda / mu

cat("\n--- HASIL CEK STEADY STATE ---\n")
```

```
##
## --- HASIL CEK STEADY STATE ---
```

```
cat("Nilai Rho (Utilitas):", round(rho, 4), "\n")
```

```
## Nilai Rho (Utilitas): 0.5875
```

```
if (rho < 1) {
  cat("System steady-state (ρ < 1)\n")
} else {
  cat("System tidak stabil (ρ >= 1)\n")
}
```

```
## System steady-state (ρ < 1)
```

```
mm1_metrics <- function(lambda, mu) {
  # Metrics
  Lq <- rho^2 / (1 - rho)
  L  <- rho / (1 - rho)
  Wq <- Lq / lambda
  W  <- L / lambda
  P0 <- 1 - rho

  # Return list hasil
  return(list(
    lambda = lambda,
    mu = mu,
    rho = rho,
    Lq = Lq,
    L = L,
    Wq = Wq,
    W = W,
    P0 = P0
  ))
}
```

```
hasil <- mm1_metrics(lambda_hat, mu_hat)
hasil
```

```
## $lambda
##      rate
## 0.5762646
##
## $mu
##      rate
## 0.9893225
##
## $rho
## [1] 0.5875491
##
## $Lq
## [1] 0.8369821
##
## $L
## [1] 1.424531
##
## $Wq
##     rate
## 1.452427
##
## $W
##     rate
## 2.472009
##
## $P0
## [1] 0.4124509
```