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ФАКУЛЬТЕТ Информатики и систем управления

КАФЕДРА Теоретической информатики и компьютерных технологий

**ЛАБОРАТОРНАЯ РАБОТА № 4**

**ПО КУРСУ:**

***«Разработка параллельных и распределенных программ»***

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**ОГЛАВЛЕНИЕ**

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# 1. Постановка задачи

Задача о пяти обедающих философах.

Суть задачи следующая. Пять философов сидят за круглым столом. Они проводят жизнь, чередуя приёмы пищи и размышления. В центра стола находится большое блюдо спагетти. Чтобы съесть порцию, каждому философу нужно две вилки. Однако, вилок всего пять: между каждой парой рядом сидящих философов лежат по одной вилке, и каждый философ может пользоваться только теми вилками, которые лежат рядом с ним, слева и справа. Философ не может брать две вилки одновременно: сначала он тратит некоторое время на то, чтобы взять одну, затем вторую. Однако, он может одновременно положить их на место. Задача заключается в том, чтобы написать программу, моделирующую поведение философов. Очевидно, что раз вилок всего пять, то одновременно есть могут не более двух философов, и два сидящих рядом философа не могут есть одновременно. Для имитации периодов раздумий и приёмов пищи можно использовать генератор случайных чисел, позволяющий задавать времена их действий в определённом интервале. Имитация поведения каждого философа, по сути, разбивается на то, что в любой момент времени философ находится в одном из пяти состояний: размышляет, берёт левую вилку, берёт правую вилку, ест, кладёт вилки на место. Таким образом, вилки являются разделяемым ресурсом.

На программу накладываются условия:

1. Каждый философ, по сути, является потоком, и модель поведения у каждого из них должна быть одинаковой, кроме того, какие вилки они могут брать.

2. Накладывание блокировки по сути является действием по взятию вилки, поэтому накладывать блокировку сразу на обе вилки нельзя; последовательность действий должна быть «наложить блокировку – взять вилку – наложить вторую блокировку – взять вторую вилку».

3. Программа должна избегать ситуации взаимоблокировки: ситуации, в которой все философы голодны, то есть ни один из них не может взять себе две вилки (например, когда каждый держит по одной и не хочет её отдавать).

Запрограммировать остановку алгоритма по достижении контрольного времени (например, атомарной операцией над булевым флагом). В отчёте построить некоторый результат работы алгоритма, которая может быть в виде графика, таблицы, лога или чего угодно ещё; главное условие состоит в том, чтобы по результатам можно было однозначно определить, чем в каждый момент времени был занят каждый философ (одно из пяти состояний). Также рассмотреть вариант программы с увеличением количества философов до

произвольного N.

# 2. Практическая реализация

import threading

import time

import random

import logging

from dataclasses import dataclass, field

from enum import Enum

from pandas import DataFrame

class CircleTable:

@dataclass

class \_\_Fork:

lock: threading.Lock = field(default\_factory=threading.Lock)

class \_\_Philosopher:

class \_\_PhilosopherState(Enum):

PONDERS = 'ponders\t\t\t'

TAKES\_LEFT\_FORK = 'takes left fork\t\t'

PUTS\_LEFT\_FORK = 'puts left fork\t\t'

TAKES\_RIGHT\_FORK = 'takes right fork\t'

EATING = 'eating\t\t\t'

PUTS\_FORKS\_IN\_PLACE = 'puts forks in place\t'

def \_\_init\_\_(self, right\_fork, left\_philosopher=None):

right\_fork: CircleTable.\_\_Fork = right\_fork

left\_philosopher: CircleTable.\_\_Philosopher = left\_philosopher

self.state = self.\_\_PhilosopherState.PONDERS

if left\_philosopher is None:

self.\_\_number: int = 1

self.right\_philosopher = self

self.left\_fork = right\_fork

self.right\_fork = right\_fork

else:

self.\_\_number: int = left\_philosopher.get\_number() + 1

self.right\_philosopher = \

left\_philosopher.right\_philosopher

self.left\_fork = left\_philosopher.right\_fork

self.right\_fork = right\_fork

self.right\_philosopher.left\_fork = right\_fork

left\_philosopher.right\_philosopher = self

def get\_number(self) -> int:

return self.\_\_number

def start\_meals(self, timeout) -> None:

end\_time = time.time() + timeout

while time.time() < end\_time:

match self.state:

case self.\_\_PhilosopherState.PONDERS:

time\_to\_ponders = random.uniform(1, 10)

logging.debug(

'\_\_Philosopher\t#%d\t%s in %f seconds',

self.get\_number(),

self.state.value,

time\_to\_ponders)

if time.time() + time\_to\_ponders >= end\_time:

break

time.sleep(time\_to\_ponders)

self.state = self.\_\_PhilosopherState.TAKES\_LEFT\_FORK

case self.\_\_PhilosopherState.TAKES\_LEFT\_FORK:

if self.left\_fork.lock.locked():

continue

self.left\_fork.lock.acquire()

time\_to\_take\_left = random.uniform(2, 4)

logging.debug(

'\_\_Philosopher\t#%d\t%s in %f seconds',

self.get\_number(),

self.state.value,

time\_to\_take\_left)

if time.time() + time\_to\_take\_left >= end\_time:

break

time.sleep(time\_to\_take\_left)

self.state = self.\_\_PhilosopherState.TAKES\_RIGHT\_FORK

case self.\_\_PhilosopherState.PUTS\_LEFT\_FORK:

time\_to\_put\_left = random.uniform(1, 2)

logging.debug(

'\_\_Philosopher\t#%d\t%s in %f seconds',

self.get\_number(),

self.state.value,

time\_to\_put\_left)

if time.time() + time\_to\_put\_left >= end\_time:

break

time.sleep(time\_to\_put\_left)

self.left\_fork.lock.release()

self.state = self.\_\_PhilosopherState.PONDERS

case self.\_\_PhilosopherState.TAKES\_RIGHT\_FORK:

if self.right\_fork.lock.locked():

if (self.right\_philosopher.state ==

self.\_\_PhilosopherState.TAKES\_RIGHT\_FORK):

self.right\_philosopher.state = \

self.\_\_PhilosopherState.PUTS\_LEFT\_FORK

continue

self.right\_fork.lock.acquire()

time\_to\_take\_right = random.uniform(2, 4)

logging.debug(

'\_\_Philosopher\t#%d\t%s in %f seconds',

self.get\_number(),

self.state.value,

time\_to\_take\_right)

if time.time() + time\_to\_take\_right >= end\_time:

break

time.sleep(time\_to\_take\_right)

self.state = self.\_\_PhilosopherState.EATING

case self.\_\_PhilosopherState.EATING:

time\_to\_eating = random.uniform(5, 10)

logging.debug(

'\_\_Philosopher\t#%d\t%s in %f seconds',

self.get\_number(),

self.state.value,

time\_to\_eating)

if time.time() + time\_to\_eating >= end\_time:

break

time.sleep(time\_to\_eating)

self.state = \

self.\_\_PhilosopherState.PUTS\_FORKS\_IN\_PLACE

case self.\_\_PhilosopherState.PUTS\_FORKS\_IN\_PLACE:

time\_to\_put = random.uniform(1, 2)

logging.debug(

'\_\_Philosopher\t#%d\t%s in %f seconds',

self.get\_number(),

self.state.value,

time\_to\_put)

if time.time() + time\_to\_put >= end\_time:

break

time.sleep(time\_to\_put)

self.left\_fork.lock.release()

self.right\_fork.lock.release()

self.state = self.\_\_PhilosopherState.PONDERS

match self.state:

case (self.\_\_PhilosopherState.PUTS\_LEFT\_FORK |

self.\_\_PhilosopherState.TAKES\_RIGHT\_FORK):

self.left\_fork.lock.release()

case (self.\_\_PhilosopherState.EATING |

self.\_\_PhilosopherState.PUTS\_FORKS\_IN\_PLACE):

self.left\_fork.lock.release()

self.right\_fork.lock.release()

def \_\_init\_\_(self):

self.\_\_last\_philosopher: CircleTable.\_\_Philosopher | None = None

def add\_philosopher(self) -> None:

self.\_\_last\_philosopher = self.\_\_Philosopher(

self.\_\_Fork(), self.\_\_last\_philosopher)

def start\_meals(

self,

timeout: int = 40,

log\_dataframe: DataFrame | None = None

) -> None:

if self.\_\_last\_philosopher is None:

return

threads: set[threading.Thread] = set()

ph = self.\_\_last\_philosopher

while True:

ph = ph.right\_philosopher

threads.add(threading.Thread(

target=ph.start\_meals, kwargs={'timeout': timeout}))

if ph == self.\_\_last\_philosopher:

break

for th in threads:

th.start()

if log\_dataframe is not None:

current\_time = 0

while True:

statuses: list[str] = []

ph = self.\_\_last\_philosopher

while True:

ph = ph.right\_philosopher

statuses.append(ph.state.value.strip())

if ph == self.\_\_last\_philosopher:

break

log\_dataframe.loc[current\_time] = statuses

if all(not th.is\_alive() for th in threads):

break

current\_time += 1

time.sleep(1)

for th in threads:

th.join()

if \_\_name\_\_ == '\_\_main\_\_':

logging.basicConfig(level=logging.DEBUG)

table = CircleTable()

N = 5

for \_ in range(N):

table.add\_philosopher()

log = DataFrame(columns=[f'philosopher #{i}'

for i in range(1, N + 1)])

log.index.name = 'time\_slice'

table.start\_meals(timeout=180, log\_dataframe=log)

print(log)

log.to\_excel("lab4/lad4.log.xlsx")

# 3. Результат работы программы

| **time\_slice** | **philosopher #1** | **philosopher #2** | **philosopher #3** | **philosopher #4** | **philosopher #5** |
| --- | --- | --- | --- | --- | --- |
| **0** | ponders | ponders | ponders | ponders | ponders |
| **1** | ponders | ponders | ponders | ponders | ponders |
| **2** | ponders | ponders | takes left fork | ponders | ponders |
| **3** | ponders | ponders | takes left fork | ponders | ponders |
| **4** | ponders | takes left fork | takes right fork | takes left fork | ponders |
| **5** | ponders | takes left fork | takes right fork | takes left fork | takes left fork |
| **6** | ponders | takes right fork | puts left fork | takes left fork | takes left fork |
| **7** | ponders | takes right fork | puts left fork | takes right fork | takes left fork |
| **8** | takes left fork | takes right fork | ponders | takes right fork | takes left fork |
| **9** | takes left fork | takes right fork | ponders | takes right fork | puts left fork |
| **10** | takes left fork | takes right fork | ponders | takes right fork | puts left fork |
| **11** | takes right fork | puts left fork | ponders | takes right fork | ponders |
| **12** | takes right fork | eating | ponders | takes right fork | ponders |
| **13** | takes right fork | eating | ponders | eating | ponders |
| **14** | takes right fork | eating | ponders | eating | ponders |
| **15** | takes right fork | eating | ponders | eating | ponders |
| **16** | takes right fork | eating | ponders | eating | takes left fork |
| **17** | takes right fork | eating | ponders | eating | takes left fork |
| **18** | takes right fork | puts forks in place | takes left fork | eating | takes left fork |
| **19** | takes right fork | ponders | takes left fork | puts forks in place | takes left fork |
| **20** | takes right fork | ponders | takes left fork | ponders | takes left fork |
| **21** | takes right fork | ponders | takes left fork | ponders | takes left fork |
| **22** | eating | ponders | takes right fork | takes left fork | takes left fork |
| **23** | eating | ponders | takes right fork | takes left fork | takes left fork |
| **24** | eating | takes left fork | takes right fork | takes left fork | takes right fork |
| **25** | eating | takes left fork | eating | takes left fork | takes right fork |
| **26** | eating | takes left fork | eating | takes left fork | takes right fork |
| **27** | eating | takes left fork | eating | takes left fork | takes right fork |
| **28** | eating | takes left fork | eating | takes left fork | takes right fork |
| **29** | eating | takes left fork | eating | takes left fork | takes right fork |
| **30** | eating | takes left fork | puts forks in place | takes left fork | takes right fork |
| **31** | puts forks in place | takes left fork | puts forks in place | takes left fork | takes right fork |
| **32** | ponders | takes left fork | ponders | takes left fork | takes right fork |
| **33** | ponders | takes left fork | ponders | takes left fork | takes right fork |
| **34** | ponders | takes left fork | ponders | takes left fork | takes right fork |
| **35** | ponders | takes right fork | ponders | takes right fork | eating |
| **36** | ponders | takes right fork | ponders | takes right fork | eating |
| **37** | ponders | takes right fork | ponders | takes right fork | eating |
| **38** | ponders | eating | ponders | takes right fork | eating |
| **39** | ponders | eating | ponders | takes right fork | eating |
| **40** | ponders | eating | ponders | takes right fork | eating |
| **41** | ponders | eating | takes left fork | takes right fork | puts forks in place |
| **42** | takes left fork | eating | takes left fork | takes right fork | ponders |
| **43** | takes left fork | eating | takes left fork | takes right fork | ponders |
| **44** | takes left fork | eating | takes left fork | takes right fork | ponders |
| **45** | takes right fork | eating | takes left fork | takes right fork | ponders |
| **46** | takes right fork | eating | takes left fork | eating | ponders |
| **47** | takes right fork | puts forks in place | takes left fork | eating | ponders |
| **48** | takes right fork | ponders | takes left fork | eating | ponders |
| **49** | takes right fork | ponders | takes left fork | eating | ponders |
| **50** | takes right fork | ponders | takes left fork | eating | ponders |
| **51** | eating | ponders | takes right fork | puts forks in place | takes left fork |
| **52** | eating | ponders | takes right fork | ponders | takes left fork |
| **53** | eating | ponders | takes right fork | ponders | takes left fork |
| **54** | eating | ponders | takes right fork | ponders | takes left fork |
| **55** | eating | takes left fork | takes right fork | ponders | takes left fork |
| **56** | eating | takes left fork | eating | ponders | takes right fork |
| **57** | eating | takes left fork | eating | ponders | takes right fork |
| **58** | eating | takes left fork | eating | ponders | takes right fork |
| **59** | eating | takes left fork | eating | ponders | takes right fork |
| **60** | eating | takes left fork | eating | ponders | takes right fork |
| **61** | puts forks in place | takes left fork | eating | ponders | takes right fork |
| **62** | puts forks in place | takes left fork | puts forks in place | takes left fork | takes right fork |
| **63** | ponders | takes left fork | puts forks in place | takes left fork | takes right fork |
| **64** | ponders | takes left fork | ponders | takes left fork | takes right fork |
| **65** | ponders | takes right fork | ponders | takes left fork | takes right fork |
| **66** | ponders | takes right fork | ponders | takes right fork | eating |
| **67** | takes left fork | eating | ponders | takes right fork | eating |
| **68** | takes left fork | eating | ponders | takes right fork | eating |
| **69** | takes left fork | eating | ponders | takes right fork | eating |
| **70** | takes left fork | eating | ponders | takes right fork | eating |
| **71** | takes left fork | eating | ponders | takes right fork | eating |
| **72** | takes left fork | eating | ponders | takes right fork | puts forks in place |
| **73** | takes left fork | puts forks in place | takes left fork | takes right fork | ponders |
| **74** | takes left fork | ponders | takes left fork | takes right fork | ponders |
| **75** | takes left fork | ponders | takes left fork | takes right fork | ponders |
| **76** | takes right fork | ponders | takes left fork | takes right fork | ponders |
| **77** | takes right fork | takes left fork | takes left fork | eating | takes left fork |
| **78** | takes right fork | takes left fork | takes right fork | eating | takes left fork |
| **79** | takes right fork | takes left fork | takes right fork | eating | takes left fork |
| **80** | eating | takes left fork | takes right fork | eating | takes left fork |
| **81** | eating | takes left fork | takes right fork | eating | takes left fork |
| **82** | eating | takes left fork | takes right fork | eating | takes left fork |
| **83** | eating | takes left fork | takes right fork | eating | takes left fork |
| **84** | eating | takes left fork | takes right fork | eating | takes left fork |
| **85** | eating | takes left fork | takes right fork | eating | takes left fork |
| **86** | eating | takes left fork | takes right fork | puts forks in place | takes left fork |
| **87** | eating | takes left fork | takes right fork | ponders | takes left fork |
| **88** | eating | takes left fork | takes right fork | ponders | takes left fork |
| **89** | puts forks in place | takes left fork | takes right fork | ponders | takes right fork |
| **90** | ponders | takes left fork | takes right fork | ponders | takes right fork |
| **91** | ponders | takes left fork | eating | ponders | takes right fork |
| **92** | ponders | takes left fork | eating | takes left fork | eating |
| **93** | takes left fork | takes right fork | eating | takes left fork | eating |
| **94** | takes left fork | takes right fork | eating | takes left fork | eating |
| **95** | takes left fork | takes right fork | puts forks in place | takes left fork | eating |
| **96** | takes left fork | takes right fork | puts forks in place | takes left fork | eating |
| **97** | takes left fork | takes right fork | ponders | takes left fork | eating |
| **98** | takes left fork | takes right fork | ponders | takes left fork | eating |
| **99** | takes left fork | eating | ponders | takes right fork | eating |
| **100** | takes left fork | eating | takes left fork | takes right fork | eating |
| **101** | takes left fork | eating | takes left fork | takes right fork | puts forks in place |
| **102** | takes left fork | eating | takes left fork | takes right fork | ponders |
| **103** | takes left fork | eating | takes left fork | takes right fork | ponders |
| **104** | takes left fork | eating | takes left fork | takes right fork | ponders |
| **105** | takes right fork | puts forks in place | takes left fork | takes right fork | ponders |
| **106** | takes right fork | puts forks in place | takes left fork | eating | takes left fork |
| **107** | takes right fork | ponders | takes left fork | eating | takes left fork |
| **108** | takes right fork | ponders | takes left fork | eating | takes left fork |
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| **112** | eating | ponders | takes right fork | eating | takes left fork |
| **113** | eating | takes left fork | takes right fork | eating | takes left fork |
| **114** | eating | takes left fork | takes right fork | eating | takes left fork |
| **115** | eating | takes left fork | takes right fork | puts forks in place | takes left fork |
| **116** | puts forks in place | takes left fork | takes right fork | puts forks in place | takes left fork |
| **117** | puts forks in place | takes left fork | takes right fork | ponders | takes left fork |
| **118** | ponders | takes left fork | takes right fork | ponders | takes left fork |
| **119** | ponders | takes left fork | takes right fork | ponders | takes left fork |
| **120** | ponders | takes left fork | eating | takes left fork | takes right fork |
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| **122** | ponders | takes right fork | eating | takes left fork | eating |
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| **125** | takes left fork | takes right fork | eating | takes left fork | eating |
| **126** | takes left fork | takes right fork | eating | takes left fork | eating |
| **127** | takes left fork | takes right fork | puts forks in place | takes left fork | eating |
| **128** | takes left fork | takes right fork | puts forks in place | takes left fork | eating |
| **129** | takes left fork | takes right fork | ponders | takes left fork | eating |
| **130** | takes left fork | takes right fork | ponders | takes left fork | eating |
| **131** | takes left fork | takes right fork | takes left fork | takes left fork | puts forks in place |
| **132** | takes left fork | eating | takes left fork | takes right fork | ponders |
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| **134** | takes left fork | eating | takes left fork | takes right fork | ponders |
| **135** | takes right fork | eating | takes left fork | takes right fork | ponders |
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| **137** | takes right fork | eating | takes left fork | eating | ponders |
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| **139** | takes right fork | puts forks in place | takes left fork | eating | ponders |
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| **147** | eating | takes left fork | takes right fork | ponders | takes left fork |
| **148** | eating | takes left fork | takes right fork | ponders | takes left fork |
| **149** | eating | takes left fork | takes right fork | ponders | takes right fork |
| **150** | eating | takes left fork | eating | takes left fork | takes right fork |
| **151** | eating | takes left fork | eating | takes left fork | takes right fork |
| **152** | puts forks in place | takes left fork | eating | takes left fork | takes right fork |
| **153** | puts forks in place | takes left fork | eating | takes left fork | takes right fork |
| **154** | ponders | takes left fork | eating | takes left fork | takes right fork |
| **155** | ponders | takes left fork | eating | takes left fork | takes right fork |
| **156** | ponders | takes left fork | eating | takes left fork | eating |
| **157** | ponders | takes left fork | eating | takes left fork | eating |
| **158** | ponders | takes right fork | puts forks in place | takes left fork | eating |
| **159** | ponders | takes right fork | puts forks in place | takes left fork | eating |
| **160** | takes left fork | takes right fork | ponders | takes left fork | eating |
| **161** | takes left fork | takes right fork | ponders | takes left fork | eating |
| **162** | takes left fork | takes right fork | ponders | takes left fork | eating |
| **163** | takes left fork | takes right fork | ponders | takes right fork | eating |
| **164** | takes left fork | eating | ponders | takes right fork | eating |
| **165** | takes left fork | eating | ponders | takes right fork | puts forks in place |
| **166** | takes left fork | eating | takes left fork | takes right fork | ponders |
| **167** | takes left fork | eating | takes left fork | takes right fork | ponders |
| **168** | takes left fork | eating | takes left fork | takes right fork | ponders |
| **169** | takes left fork | eating | takes left fork | takes right fork | ponders |
| **170** | takes right fork | eating | takes left fork | eating | ponders |
| **171** | takes right fork | eating | takes left fork | eating | ponders |
| **172** | takes right fork | puts forks in place | takes left fork | eating | ponders |
| **173** | takes right fork | ponders | takes left fork | eating | ponders |
| **174** | takes right fork | ponders | takes left fork | eating | takes left fork |
| **175** | takes right fork | ponders | takes right fork | eating | takes left fork |