Санкт-Петербургский государственный политехнический университет Институт Информационных Технологий и Управления Кафедра компьютерных систем и программных технологий

Отчет по расчетной работе № 3 по предмету «Системное программное обеспечение»

Примитивы синхронизации в ОС Windows

Постановка задачи

В рамках данной работы необходимо ознакомиться с основными примитивами синхронизации в ОС Windows, и выполнить следующие задачи:

- 1. Привести собственные результаты выполнения предложенных программ и их анализ:
 - Использование мьютексов
 - Использование семафоров
 - Критические секции
 - Объекты-события в качестве средства синхронизации
 - Условные переменные
 - Задача читатели и писатели
 - Решение задачи читатели-писатели для потоков разных процессов с синхронизапией объектами
- 2. Модифицировать предложенное решение таким образом, чтобы читатели не имели доступа к памяти по записи.
- 3. Предложить более рациональное решение задачи читатели-писатель, используя другие средства синхронизации или их сочетание. Объяснить и подтвердить экспериментально улучшение характеристик взаимодействия.
- 4. Разработать клиент-серверное приложение для полной задачи читатели-писатели с собственной системой ограничений на доступ каждого читателя к информации.
- 5. Разработать программу читатели-писатели для сетевого функционирования. Для этого выбрать подходящие средства IPC и синхронизации.
- 6. Предложить программное решение задачи производители-потребители (разница с предыдущей задачей возможность модификации считываемых данных).
- 7. Решить задачу обедающие философы, обосновать выбранные средства синхронизации.

Исходный код всех представленных листингов доступен по адресу https://github.com/SemenMartynov/SPbPU_SystemProgramming.

1.1 Использование мьютексов

```
C:\Users\win7\Documents\Visual Studio 2013\Projects\SynchronizationPrimitives\Debug\Mutex.exe
                                                                                                                                                   - - X
                                                             AMMsg
numMsg=
y numMsg=
4 numMsg=
5 numMsg=
7 num
1
                                        "writer_id = 9 numMsg=
                   put data:
                                                                                                  in position
                                                                                                                                                                          .
                                        "writer_id = "writer_id =
                                                                                           13"
Writer 4
Reader 2
                   put data:
                                                                                                    in position
                                                                                          13" from position 6
                   get data:
                                        "writer_id
"writer_id
"writer_id
                                                                                          13" from position
13" from position
13" in position 8
13" from position
13" in position 9
Reader 1
Writer 5
Reader 5
Writer 7
Reader 0
                   get data:
put data:
                   get data:
                                        "writer_id
"writer_id
                   put data:
                                                                                           13" from position
                   get data:
                                                                                                  in position 0 from position 1 from position 1 from position 2 from position 2
                                        "writer_id
"writer_id
"writer_id
                                                                                          14"
                                                                   1 numMsg=
1 numMsg=
                   put data:
get data:
               1
9
 Writer
                                                                                          14"
14"
14"
                                                               =
                                                                                                                                0
 Reader
                                                                       numMsg=
                                                               = O numMsg=
 Writer O
                   put data:
                                        "writer_id
"writer_id
                   get data:
put data:
 Reader 6
                                                                       numMsg=
                                                                                           14"
                                                                      numMsg=
 Writer 8
                                                                   8
                                       "writer_id
"writer_id
"writer_id
"writer_id
 Reader 2
Writer 6
                   get data:
put data:
                                                               = 8 numMsg=
                                                                                           14"
                                                                                                  from position in position 3
                                                                                                                                2
                                                                                          14"
14"
14"
                                                               =
                                                                   6
                                                                       numMsg=
                                                                                                  in position 4 from position from position
               335
                                                               =
 Writer
                   put data:
                                                                   3
                                                                      numMsg=
                                        "writer_id
"writer_id
                   get data:
                                                                       numMsg=
 Reader
                                                                   3 numMsg=
2 numMsg=
2 numMsg=
                                                                                           14"
                   get data:
 Reader
                                                                                                  from posicion 5 in position 5 from position in position 6 in position 7
                                                                                                                                 4
                                       "writer_id
"writer_id
"writer_id
"writer_id
"writer_id
"writer_id
Writer 2
Reader 0
                   put data:
get data:
                                                                                           14"
                                                                                          14"
14"
14"
                                                               = 4 numMsg=
= 9 numMsg=
 Writer 4
Writer 9
                   put data:
                   put data:
                                                                       numMsg=
Writer 7 put data: Writer
Reader 1 get data: "Writer
Reader 2 finishing work
Reader 4 finishing work
TimeManager finishing work
                                                                                           14" from position 6
                                                               = 4 numMsg=
Writer 5 finishing work
Reader 3 finishing work
Reader 5 finishing work
Writer 7 finishing work
Reader 0 finishing work
                   finishing work
 Writer
               1
                  finishing work
finishing work
finishing work
finishing work
finishing work
 Writer O
 Reader 9
 Writer 8
 Reader 8
                   finishing work
finishing work
finishing work
finishing work
finishing work
 Reader 6
Reader 7
Reader
 Writer 6
Reader 1
Writer 3
Writer 2
Writer 4
Writer 9
                  finishing work
finishing work
finishing work
                                                                                                                                                                          Ξ
  all is done
```

Рис. 1: Использование мьютексов.

1.2 Использование семафоров

```
💷 C:\Users\win7\Documents\Visual Studio 2013\Projects\SynchronizationPrimitives\Debug\Semaphor... 👝 🕒 🔼
                                                             "writer_id
"writer_id
                            get data:
                                                                                               = 6 numMsg=
                                                                                                                                                    from position
                                                                                                                                        1Ö"
                             put
                                         data:
                                                                                                           numMsg=
                                                                                                                                                      in position
 Writer
                                                                                                                                       10" in position ?
10" in position 8
10" in position 9
10" from position
10" from position 0
11" in position 0
                                                            "writer_id
"writer_id
"writer_id
                      47
                            put data:
put data:
                                                                                                      \frac{2}{4}
 Writer
                                                                                                           numMsg=
 Writer
                                                                                                           numMsg=
                      .
9
5
                                                                                                           numMsg=
 Reader
                            get
                                        data:
                                                            "writer_id
"writer_id
                                                                                                          numMsg=
numMsg=
                                                                                                                                       10" from position
11" in position 0
11" in position 1
10" from position
11" in position
11" in position
211" in position 3
11" in position 3
11" in position 4
11" from position
11" from position
11" from position
11" from position
11" in position 5
11" from position
11" in position 6
11" from position
11" in position 6
11" from position
11" in position 7
11" in position 9
12" in position 9
12" in position 0
11" from position
11" from position
12" in position 1
11" from position
12" in position 2
12" in position 3
12" from position
12" in position 4
12" from position
12" from position
12" in position 5
12" from position
12" in position 5
12" from position 6
                            get
 Reader
                                         data:
                                                                                                                                        10"
11"
11"
10"
                            put data:
 Writer
                                                            "writer_id
"writer_id
"writer_id
"writer_id
 Writer O
                                                                                                     0 numMsg=
7 numMsg=
                            put data:
get data:
 Reader 4
Reader 0
                                                                                                           numMsg=
                                                                                                    ₿
                                                                                                          numMsg=
                            get
                                        data:
                                                                                                                                                                                                 0
                                                                                                    8 numMsg=
2 numMsg=
3 numMsg=
0 numMsg=
                                                            "writer_id
"writer_id
Writer 8
Writer 2
Writer 3
Reader 5
                            put data:
put data:
                                                            "writer_id
"writer_id
"writer_id
"writer_id
                            put data:
get data:
                                                                                               =
 Reader 1
Reader 8
Writer 9
                                                                                               = 8
= 2
= 9
 Reader
                            get data:
                                                                                                          numMsg=
                                                            "writer_id
"writer_id
                                                                                                          numMsg=
numMsg=
                            get data:
put data:
 Writer
                                                            "writer_id
"writer_id
"writer_id
"writer_id
                                                                                                    3 numMsg=
6 numMsg=
9 numMsg=
6 numMsg=
 Reader 2
Writer 6
                            get data:
put data:
                            get data:
get data:
put data:
 Reader 6
Reader 7
                                                                                               "writer_id
"writer_id
                                                                                                          numMsg=
numMsg=
 Writer
                                                                                                     1
                                                            "writer_id
"writer_id
"writer_id
                                                                                               = 4 numMsg=
= 7 numMsg=
 Writer 4
Writer 7
                            put data:
put data:
                                                                                                           numMsg=
 Writer 5
Reader 3
Writer 0
                                                                                               = 5
                            put data:
                                                                                                          numMsg=
                                                            "writer_id
"writer_id
                            get data:
put data:
                                                                                                    1 numMsg=
0 numMsg=
 Writer
                                                           "writer_id
"writer_id
"writer_id
"writer_id
 Reader 9
                                                                                               = 4 numMsg=
= 7 numMsg=
                            get data:
get data:
Reader 9
Reader 4
Writer 8
Writer 2
Reader 0
Writer 3
Reader 5
Writer 6
                                                                                                           numMsg=
                                                                                               = 8
                            put data:
                                                                                                          numMsg=
                                                          "writer_id
"writer_id
"writer_id
"writer_id
"writer_id
"writer_id
                                                                                                    2 numMsg=
5 numMsg=
3 numMsg=
                            put data:
get data:
                                                                                                                                                                                                 0
                            put data:
get data:
                                                                                               =
                                                                                               =
                                                                                                     0
                                                                                                           numMsg=
Reader 8 get data: "writer_id = 0 numMsg=
Reader 5 get data: "writer_id = 8 numMsg=
Writer 6 put data: "writer_id = 6 numMsg=
Reader 1 get data: "writer_id = 2 numMsg=
Writer 9 put data: "writer_id = 9 numMsg=
TimeManager finishing work
Reader 2 finishing work
Reader 7 finishing work
Reader 6 finishing work
Reader 9 finishing work
Reader 9 finishing work
Reader 9 finishing work
Reader 9 finishing work
TimeManag
Reader 2
Reader 7
Reader 3
Reader 9
Reader 4
Reader 0
Reader 5
Reader 8
Writer 7
                           finishing work
finishing work
finishing work
finishing work
finishing work
finishing work
 Writer 1
                            finishing
finishing
finishing
 Reader 1
                                                            work
 Writer 4
Writer 5
                                                            work
                            finishing
finishing
  Writer O
                                                            work
 Writer 8
                                                            work
Writer 6 fi
Writer 2 fi
Writer 3 fi
Writer 6 fi
Writer 9 fi
all is done
                            finishing work
finishing work
finishing work
finishing work
finishing work
```

Рис. 2: Использование семафоров.

1.3 Критические секции

```
💷 C:\Users\win7\Documents\Visual Studio 2013\Projects\SynchronizationPrimitives\Debug\CriticalSe... 👝 🕒 🔼
                                                                                                                                  12"
12"
12"
12"
12"
12"
12"
                                                            "writer_id
"writer_id
    Writer 7
Reader 9
                                                                                                  7 numMsg=
7 numMsg=
8 numMsg=
                             put data:
                                                                                                                                               in position O
                              get data:
                                                                                                                                               from position
   Reader
                                                           "writer_id
"writer_id
"writer_id
"writer_id
                                                                                                                                              in position 1
from position
in position 2
                             put data:
get data:
    Writer 8
                                                                                                       numMsg=
   Reader 8
                                                                                                  8
                                                                                                       numMsg=
  Writer 3
Reader 7
Writer 2
Writer 9
Reader 3
Reader 6
                                                                                                  3 numMsg=
3 numMsg=
2 numMsg=
                             put data:
                                                                                            =
                                                           "writer_id
"writer_id
                             get
                                        data:
                                                                                                                                               from position
                              put data:
                                                                                                                                               in position 3
                                                                                                                                  12" in position 3
12" in position 4
12" from position
12" from position
12" in position 5
12" from position
12" in position 6
12" in position 7
12" from position
12" from position
12" from position
12" in position 8
12" from position 8
12" from position 9
12" from position 9
                                                           "writer_id
"writer_id
"writer_id
"writer_id
                             put data:
get data:
                                                                                                       numMsg=
                                                                                                  2
                                                                                                       numMsg=
                             get data:
put data:
get data:
                                                                                                  944
                                                                                                       numMsg=
                                                           "writer_id
"writer_id
                                                                                                      numMsg=
numMsg=
    Writer 4
Reader 4
   Reader
                                                           "writer_id
"writer_id
"writer_id
"writer_id
   Writer 5
                             put data:
put data:
                                                                                                 5
                                                                                                       numMsg=
   Writer
                                                                                            numMsg=
   Reader 8
Reader 2
Writer 6
Reader 0
                             get data:
get data:
put data:
                                                                                            = 5
                                                                                                       numMsg=
                                                                                                                                  12" from position
12" in position 8
12" from position 8
12" from position 9
12" in position 9
12" from position 13" in position 1
13" from position 1
13" from position 13" in position 2
13" from position 2
13" from position 3
13" from position 3
13" from position 4
13" from position 4
13" from position 5
13" from position 5
                                                           "writer_id
"writer_id
                                                                                                      numMsg=
numMsg=
                                                                                                  1
                                                                                                  6
                                                           "writer_id
"writer_id
"writer_id
"writer_id
                             get data:
put data:
                                                                                            = 6 numMsg=
   Writer O
                                                                                            =
                                                                                                 0
                                                                                                       numMsg=
                                                                                                 O numMsg=
7 numMsg=
8 numMsg=
7 numMsg=
8 numMsg=
                       3
7
                             get data:
   Reader
                                                                                            =
                                                           "writer_id
"writer_id
                             put data:
put data:
    Writer
                       8
9
   Writer
                                                           "writer_id
"writer_id
"writer_id
"writer_id
                             get data:
get data:
   Reader
                                                                                            =
   Reader 8
                                                                                            =
  Writer 3
Reader 5
Writer 2
Reader 0
Writer 9
                             put data:
                                                                                                       numMsg=
                                                                                                  332
                                                           "writer_id
"writer_id
                             get data:
put data:
                                                                                                       numMsg=
numMsg=
writer_id

put data: "writer_id

put data: "writer_id

r 3 get data: "writer_id

writer 5 put data: "writer_id

Writer 1 put data: "writer_id

Reader 9 get data: "writer_id =

Reader 8 finishing work

TimeManager finishing work

Writer 6 finishing work

Writer 6 finishing work

Reader 5 finishing work

Reader 7 finishing work

Reader 9 finishing work

writer 0 finishing work

leader 1 finishing work

eader 1 finishing work

riter 7 finishing

riter 8
                                                           "writer_id
"writer_id
"writer_id
"writer_id
                             get data:
put data:
                                                                                                  2
9
9
                                                                                            =
                                                                                                       numMsg=
                                                                                                       numMsg=
                                                                                                       numMsg=
                                                                                                  4 numMsg=
                                                                                                                                  13" from position 5
13" from position 6
13" in position 7
13" from position 6
                                                                                                  \bar{4}
                                                                                                       numMsg=
                                                                                           = 5
                                                                                                       numMsg=
                                                                                            = 1 numMsg=
= 5 numMsg=
   Reader 1
Writer 7
Reader 3
Writer 8
                             finishing
finishing
finishing
finishing
finishing
finishing
   Reader 6
                                                           work
   Reader 6
Writer 3
Reader 9
Writer 2
Writer 9
                                                           work
                                 inishing work
                             finishing work
finishing work
finishing work
finishing work
finishing work
finishing work
   Writer 4
Writer 5
                             finishing work
    Writer 1
    all is done
```

Рис. 3: Критические секции.

1.4 Объекты-события в качестве средства синхронизации

```
- - X
             C:\Users\win7\Documents\Visual Studio 2013\Projects\SynchronizationPrimitives\Debug\Event.exe
                                                                                     "writer_id
"writer_id
                                                                                                                                                                                11"
11"
                                              get data:
                                                                                                                                     3 numMsg=
                                                                                                                                                                                               from position from position
                                                                                                                                             numMsg=
                                              get
                                                           data:
            Reader
                                                                                                                                                                                              in position 4 in position 5 from position from position in position 6
                                                                                   "writer_id
"writer_id
"writer_id
                                                                                                                                                                                11"
11"
                                              put data:
put data:
            Writer
                                      52
                                                                                                                                      5
2
                                                                                                                                            numMsg=
            Writer
                                                                                                                                             numMsg=
                                                                                                                             - 52
- 27
- 7
- 7
                                                                                                                                                                                11"
           Reader O
                                              get
                                                           data:
                                                                                                                                            numMsg=
                                                                                                                                                                                11"
                                                                                    "writer_id
"writer_id
                                                                                                                                            numMsg=
numMsg=
             Reader
                                              get
                                                            data:
                                                                                                                                                                                111"
                                              put data:
            Writer
                                                                                   "writer_id
"writer_id
"writer_id
                                                                                                                                                                                11"
11"
            Reader 4
Writer 9
                                                                                                                                                                                               from position in position 7
                                              get data:
put data:
                                                                                                                                            numMsg=
                                                                                                                                            numMsg=
                                                                                                                             = 9 numMsg=
= 9 numMsg=
= 4 numMsg=
= 4 numMsg=
                                                                                                                                                                                11" from position 11" in position 8
            Reader 8
                                              get
                                                           data:
                                                                                    "writer_id
"writer_id
            Writer 4
Reader 0
                                              put
                                                           data:
                                                                                                                                                                                111"
                                              get data:
                                                                                                                                                                                                from position
                                                                                                                                                                                11"
11"
                                                                                                                                                                                               in position 9
from position
in position 0
from position
                                                                                   "writer_id
"writer_id
"writer_id
"writer_id
            Writer 8
                                              put data:
get data:
                                                                                                                              = 8
                                                                                                                                           numMsg=
                                                                                                                              = 8
            Reader 6
                                                                                                                                            numMsg=
            Writer 1
Reader 1
Writer 3
Reader 3
Writer 0
                                                                                                                                     1 numMsg=
1 numMsg=
3 numMsg=
3 numMsg=
                                                                                                                                                                                12"
12"
                                              put data:
                                                                                    "writer_id
"writer_id
                                              get
                                                            data:
                                                                                                                                                                               12"
12"
12"
                                                                                                                                                                                                 in position 1
                                              put data:
                                                                                   "writer_id
"writer_id
"writer_id
                                                                                                                                                                                               from position in position 2
                                             get data:
put data:
                                                                                                                              =
                                                                                                                              = 0
                                                                                                                                            numMsg=
                                                                                                                                                                                12" from position
12" in position 3
                                              get data:
            Reader 9
                                                                                                                              = 0 numMsg=
                                                                                    "writer_id
"writer_id
             Writer 6
                                              put
                                                           data:
                                                                                                                                      6
                                                                                                                                           numMsg=
                                                                                                                                                                              12" in position
12" from position
12" in position 4
12" in position 5
12" from position
12" from position
12" from position
                                              get data:
                                                                                                                                            numMsg=
                                     4
                                                                                                                                     652527
            Reader
                                                                                   "writer_id
"writer_id
"writer_id
            Writer 5
Writer 2
                                              put data:
put data:
                                                                                                                              =
                                                                                                                                           numMsg=
                                                                                                                              =
                                                                                                                                            numMsg=
Reader b
Writer 7 put
Reader 3 get data:
Writer 9 put data:
Writer 9 put data:
Writer 4 get data: "Writer
Writer 4 put data: "Writer
Reader 5 finishing work
TimeManager finishing work
TimeManager finishing work
Reader 0 finishing work
Writer 1 finishing work
Writer 1 finishing work
Writer 3 finishing work
Writer 3 finishing work
Writer 3 finishing work
TimeManager finishing work
Writer 1 finishing work
Writer 2 finishing work
Writer 3 finishing work
The Manager finishing work
Writer 3 finishing work
Writer 3 finishing work
Writer 4 finishing work
Writer 5 finishing work
Writer 6 finishing work
Writer 7 work
Writer 8 work
Writer 9 put data:
Writer 9 pu
            Reader O
                                              get data:
                                                                                                                                            numMsg=
                                                                                    "writer_id
"writer_id
                                                                                                                                           numMsg=
numMsg=
                                                                                                                                                                               12" in position 6
12" from position 6
12" from position 7
12" in position 7
                                                                                  "writer_id = 7 numMsg=
"writer_id = 7 numMsg=
"writer_id = 9 numMsg=
"writer_id = 9 numMsg=
"writer_id = 4 numMsg=
                                                                                                                                                                                12" in position 8
                                            finishing work
finishing work
finishing work
finishing work
finishing work
           Reader 9
Reader 4
Reader 2
Reader 7
Writer 2
Writer 5
                                             finishing
finishing
finishing
                                                                                    work
                                                                                    work
                                                                                    work
                                              finishing
finishing
                                     8
7
            Reader
                                                                                    work
            Writer
                                                                                   work
           Writer 9 finishing work
Writer 4 finishing work
all is done
```

Рис. 4: Объекты-события в качестве средства синхронизации.

1.5 Условные переменные

```
🖭 C:\Users\win7\Documents\Visual Studio 2013\Projects\SynchronizationPrimitives\Debug\Condition... 👝 🕒 📧
                                                                                            4 numMsg=
7 numMsg=
7 numMsg=
0 numMsg=
                                                                                                                             11"
11"
11"
11"
                                                        "writer_id
"writer_id
 Reader 3
Writer 7
                          get data:
                                                                                                                                        from position 2
                           put data:
                                                                                                                                          in position 3
 Writer
                                                       "writer_id =
"writer_id =
"writer_id =
"writer_id =
 Reader 9
Writer 0
                                                                                                                             11" from position 11" in position 4 11" from position 4 11" in position 5 11" from position 6
                          get data:
put data:
                                                                                       = O numMsg=
 Reader O
                          get data:
                                                       "writer_id
"writer_id
                                                                                                 numMsg=
numMsg=
                          put data:
  driter 6
                                                                                             6
                          get data:
 Reader 4
                                                                                             6
                                                       "writer_id
"writer_id
"writer_id
"writer_id
                                                                                                                                        in position 6
from position
in position 7
from position 9
Writer 5
Reader 7
                                                                                       = 5 numMsg=
= 5 numMsg=
                                                                                                                             11"
                          put data:
get data:
                                                                                                                             11"
                                                                                                  numMsg=
                                                                                                                             11"
11"
12"
Writer 8 put data: "writer_id = 8 numMsg=
Reader 1 get data: "writer_id = 8 numMsg=
Writer 2 put data: "writer_id = 2 numMsg=
Reader 8 get data: "writer_id = 2 numMsg=
TimeManager finishing work
Reader 1 finishing work
Writer 3 put data: "writer_id = 3 numMsg=
Reader 4 get data: "writer_id = 3 numMsg=
Writer 4 put data: "writer_id = 4 numMsg=
Reader 2 get data: "writer_id = 4 numMsg=
Reader 2 finishing work
 Writer 8
                                                                                       = 8 numMsg=
                          put data:
                                                                                                                                          in position 8
                                                                                                                             12" from position 8
                                                                                                                             12" in position 9
12" from position 9
12" in position 0
12" from position 0
Writer 4
Reader 2
Writer 2
Writer 8
                          put data:
get data:
finishing
finishing
                                                       work
                                                      work
work
"writer_id = 0 numMsg=
"writer_id = 0 numMsg=
"writer_id = 6 numMsg=
"writer_id = 9 numMsg=
"writer_id = 5 numMsg=
                                                                                                                             12" in position 1
12" from position
12" in position 2
11" in position 3
12" in position 4
                    ŏ
?
 Writer
                          put data:
                          get data:
put data:
 Reader
 Writer 6
 Writer 9
                          put data:
                                                       "writer_id = 5 numMsg=
"writer_id = 6 numMsg=
"writer_id = 9 numMsg=
"writer_id = 7 numMsg=
                                                                                                                             12" in position 4
12" from position
11" from position
 Writer 5
Reader 0
                          put data:
get data:
 Reader
Reader 5
iter 7
                          get data:
put data:
finishing
                                                                                                                              12" in position 5
                                                      writer_id = 7 numMsg=
work
"writer_id = 5 numMsg=
"writer_id = 7 numMsg=
"writer_id = 1 numMsg=
"writer_id = 1 numMsg=
 Reader 8
                                                                                                                            12" from position 4
12" from position 5
11" in position 6
                          get data:
get data:
 Reader
                     3
 Reader 6
Writer 1
Reader 9
Reader 4
Reader 2
Reader 7
                          put data: "writ
get data: "writ
finishing work
                                                                                                                             11" from position 6
Reader 4 finishing work
Reader 2 finishing work
Reader 7 finishing work
Reader 0 finishing work
Reader 5 finishing work
Reader 6 finishing work
Reader 5
Reader 5
Reader 3
Writer 3
Writer 4
Reader 9
Writer 0
                          finishing work
finishing work
finishing work
finishing work
finishing work
 writer of inishing work
Writer 5 finishing work
Writer 6 finishing work
Writer 9 finishing work
Writer 7 finishing work
Writer 1 finishing work
                                                                                                                                                                                                                                           Ε
  all is done
```

Рис. 5: Условные переменные.

1.6 Задача читатели и писатели

```
🖭 C:\Users\win7\Documents\Visual Studio 2013\Projects\SynchronizationPrimitives\Debug\ThreadsR... 😊 🕒 🔀
                                                  "writer_id 0, msg with num "writer_id 0, msg with num
                                                                                                                                   142"
142"
142"
                         read msg
 Reader
                    3
                         read
                                      msg
                                                 "writer_id 0, msg with num =
Reader 4
Reader 9
                         read
                                      msg
                                                                                                                                   142"
                         read msg
                                                                                                                                   142"
Reader 6
Reader 7
                         read msg
                         read msg "writer_id U, msg with num = 142"
read msg "writer_id O, msg with num = 142"
ut msg: "writer_id O, msg with num = 143"
read msg "writer_id O, msg with num = 143"
read msg "writer_id O, msg with num = 143"
read msg "writer_id O, msg with num = 143"
 Reader
                   put msg:
9 read me
 writer
 Reader
Reader
Reader 0
                                                 "writer_id 0, msg with num =
                                                                                                                                    143"
 Reader
                         read
                                       msg
 Reader
                         read msg
 Reader 8
                                                                                                                                   143"
                         read msg
                                                                                                                                   143"
 Reader 6
                         read msg
                                                                                                                                   143"
 Reader 1
                         read msg
                        read msg "writer_id 0, msg with num = 143"
read msg "writer_id 0, msg with num = 143"
read msg "writer_id 0, msg with num = 144"
ut msg: "writer_id 0, msg with num = 144"
read msg "writer_id 0, msg with num = 144"
read msg "writer_id 0, msg with num = 144"
Reader 4
Reader 7
writer put msg:
Reader 2 read ms
Reader 5 read ms
Reader 7 read ms
Reader 9 read ms
                                                 "writer_id 0, msg with num =
                                                                                                                                   144"
                         read msg
                         read msg
                                                                                                                                   144"
                         read msg
Reader
 Reader 0
                         read msg
Reader 4
Reader 3
Reader 6
                         read msg
                                                  "writer_id O, msg with num =
"writer_id O, msg with num =
"writer_id O, msg with num =
                                                                                                                                   144"
                         read msg
                         read msg
                       read msg "writer_id 0, msg with num = 144"
read msg "writer_id 0, msg with num = 144"
ut msg: "writer_id 0, msg with num = 145"
read msg "writer_id 0, msg with num = 145"
read msg "writer_id 0, msg with num = 145"
read msg "writer_id 0, msg with num = 145"
read msg "writer_id 0, msg with num = 145"
read msg "writer_id 0, msg with num = 145"
read msg "writer_id 0, msg with num = 145"
Reader 8
                   put msg:
3 read ms
 writer
 Reader
 Reader
 Reader
Keader 2
Reader 0
 Reader 8
                        read msg "writer_id 0, msg ...
read msg "writer_id 0, msg with num = 145"
read msg "writer_id 0, msg with num = 145"
 Reader 6
 Reader 6
                        finishing "writer_id o, read msg "writer_id o, finishing work finishing work finishing work read msg "writer_id O, msg with num = 145"
 Reader
 Reader
Writer O
Reader 7
Reader 7
                        read msg "writer_id 0, msg ...
finishing work
read msg "writer_id 0, msg with num = 145"
read msg "writer_id 0, msg with num = 145"
Reader 7 Inions
Reader 4 read msg "writer_
TimeManager finishing work
Reader 4 finishing work
Reader 2 finishing work
 Reader 4
Reader 2
Reader 5
                         finishing
                                                    work
                        finishing work
finishing work
finishing work
finishing work
 Reader 0
                                                                                                                                                                                                                                 Ε
                   Ò
 Reader
 Reader 8
Reader
                   3
 all is done
```

Рис. 6: Задача читатели и писатели.

1.7 Решение задачи читатели-писатели для потоков

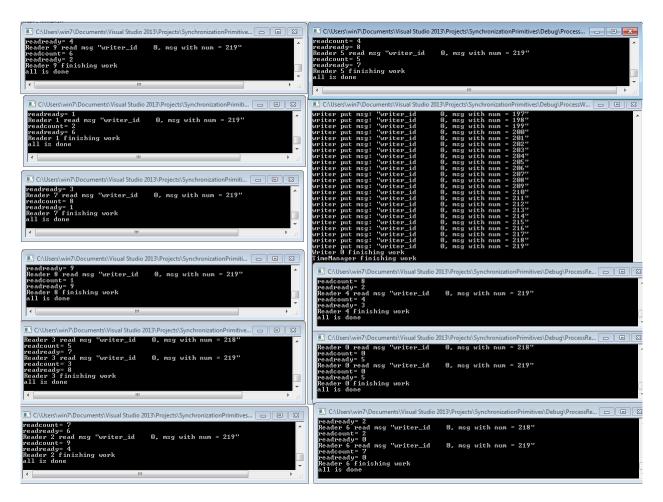


Рис. 7: Решение задачи читатели-писатели для потоков.

2 Модификация задачи читатели-писатели без доступа читателей на запись

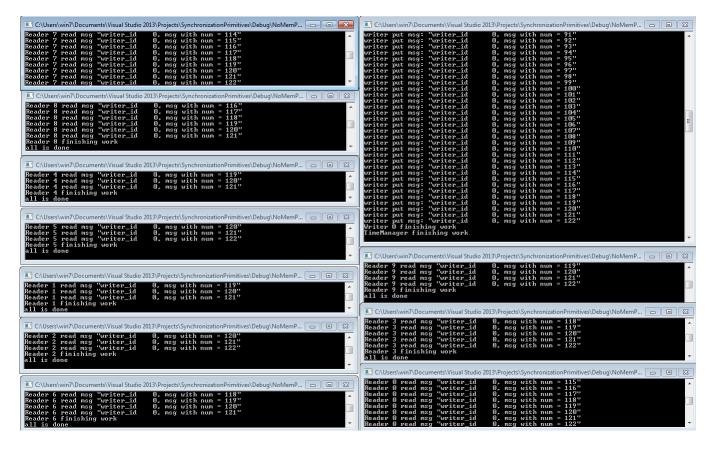


Рис. 8: Модификация задачи читатели-писатели.

Выводы