

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

**ПРИМИТИВЫ СИНХРОНИЗАЦИИ В ОС WINDOWS**

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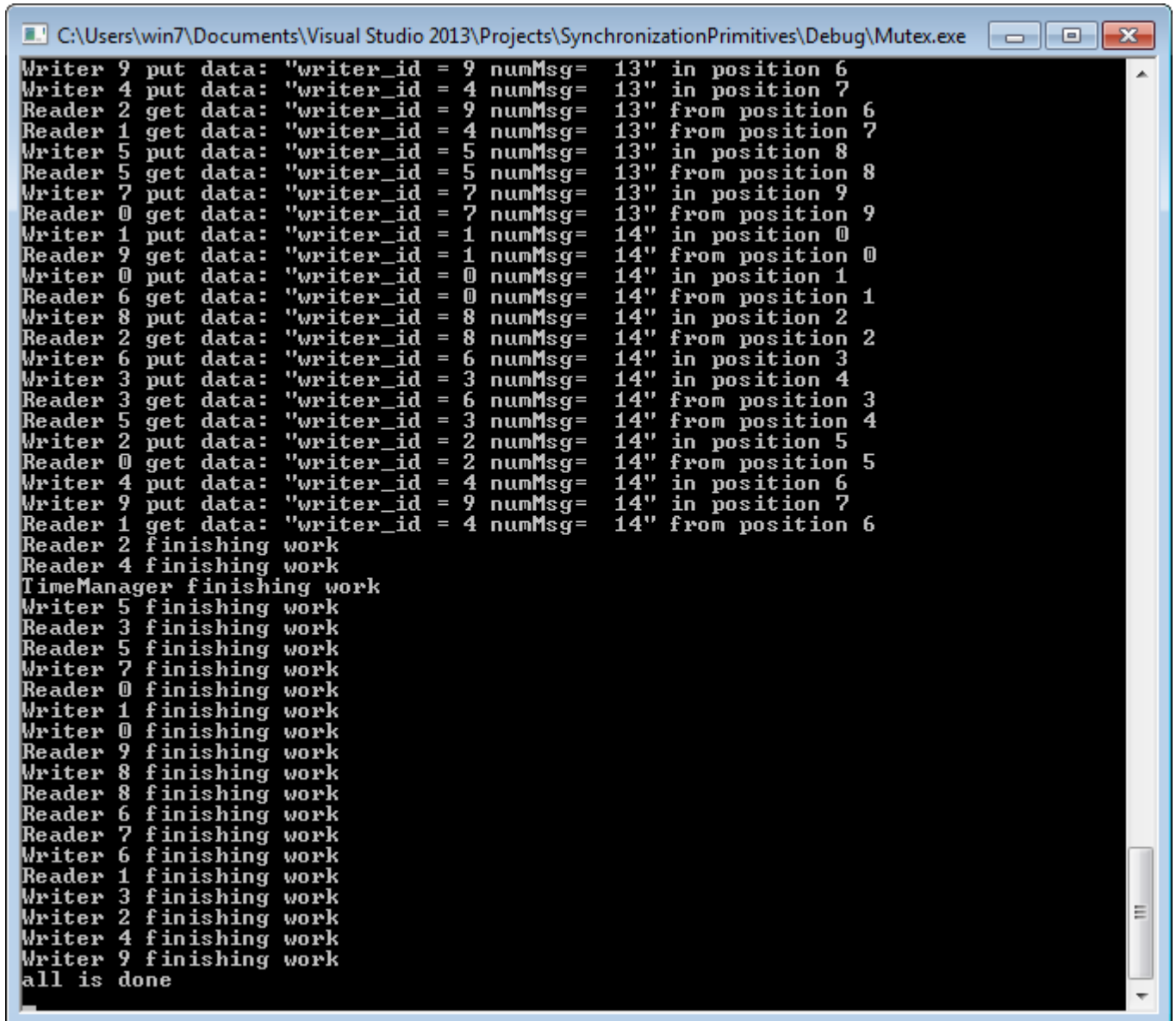
# Постановка задачи

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 читателя и писателя
  - Решение задачи читателя-писателя для потоков разных процессов с синхронизацией объектами
2. Модифицировать предложенное решение таким образом, чтобы читатели не имели доступа к памяти по записи.
3. Предложить более рациональное решение задачи читателя-писатель, используя другие средства синхронизации или их сочетание. Объяснить и подтвердить экспериментально улучшение характеристик взаимодействия.
4. Разработать клиент-серверное приложение для полной задачи читателя-писателя с собственной системой ограничений на доступ каждого читателя к информации.
5. Разработать программу читателя-писателя для сетевого функционирования. Для этого выбрать подходящие средства IPC и синхронизации.
6. Предложить программное решение задачи производителя-потребителя (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](https://github.com/SemenMartynov/SPbPU_SystemProgramming).

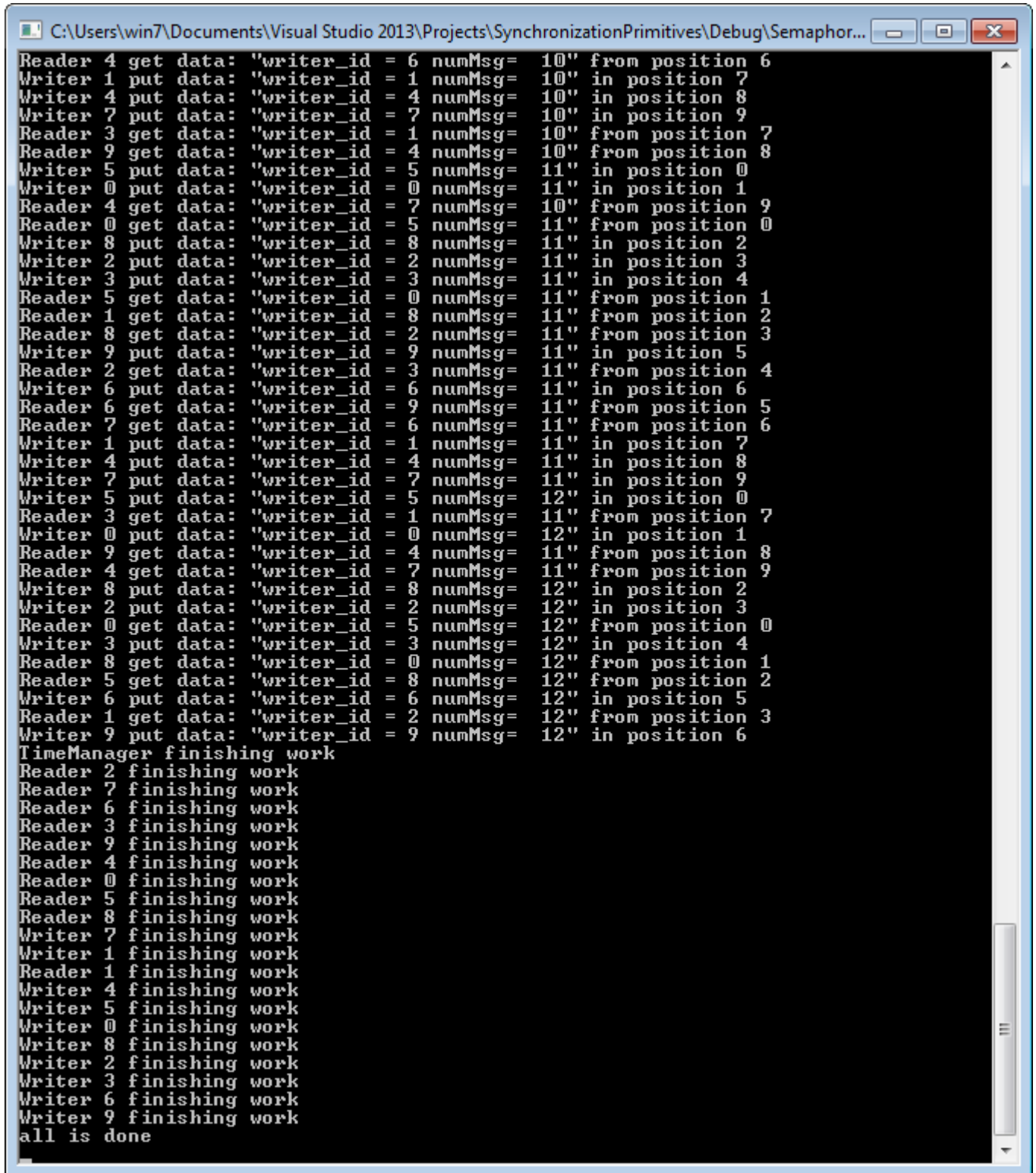
## 1.1 Использование мьютексов



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

Рис. 1: Использование мьютексов.

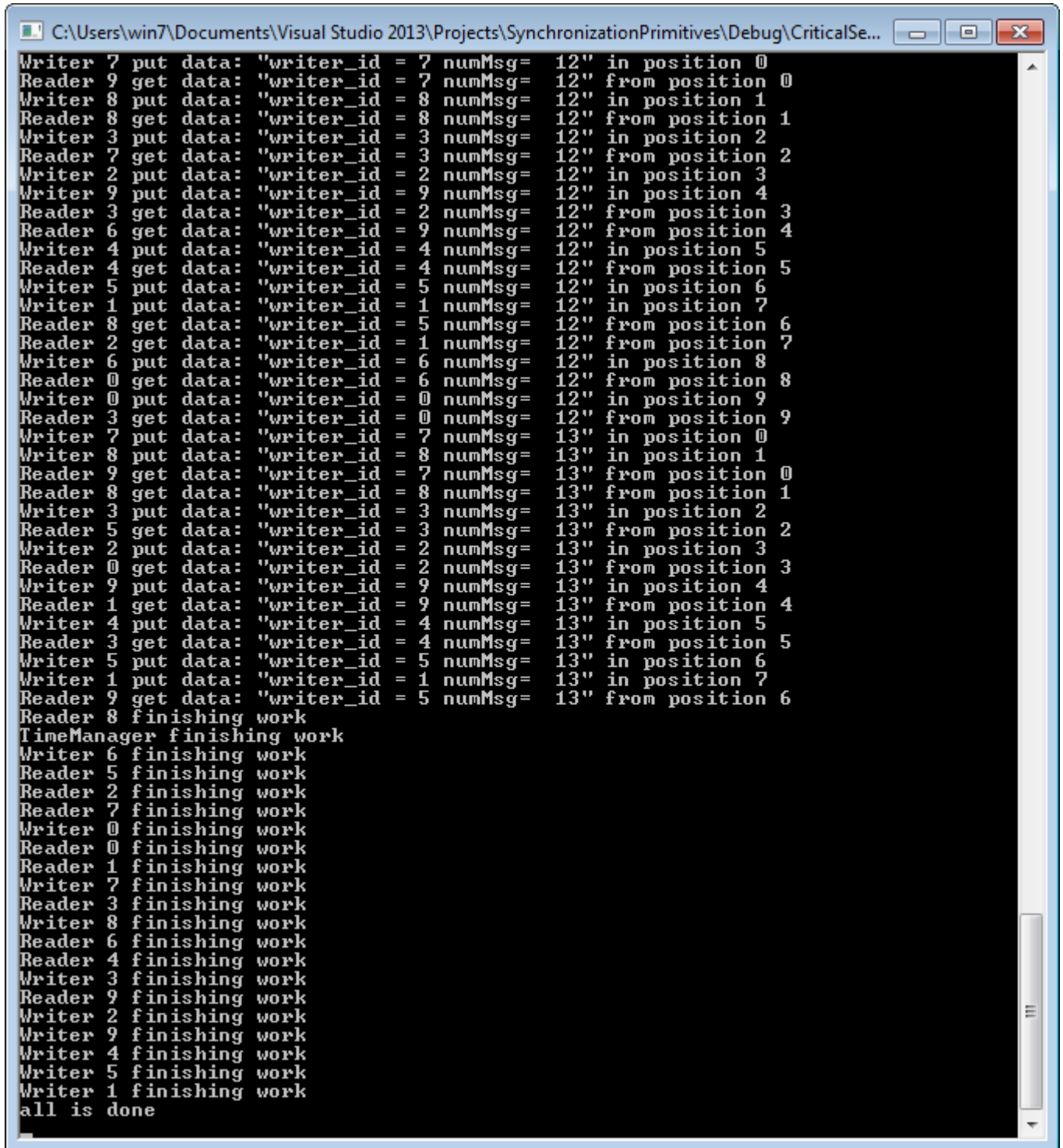
## 1.2 Использование семафоров



```
Reader 4 get data: "writer_id = 6 numMsg= 10" from position 6
Writer 1 put data: "writer_id = 1 numMsg= 10" in position 7
Writer 4 put data: "writer_id = 4 numMsg= 10" in position 8
Writer 7 put data: "writer_id = 7 numMsg= 10" in position 9
Reader 3 get data: "writer_id = 1 numMsg= 10" from position 7
Reader 9 get data: "writer_id = 4 numMsg= 10" from position 8
Writer 5 put data: "writer_id = 5 numMsg= 11" in position 0
Writer 0 put data: "writer_id = 0 numMsg= 11" in position 1
Reader 4 get data: "writer_id = 7 numMsg= 10" from position 9
Reader 0 get data: "writer_id = 5 numMsg= 11" from position 0
Writer 8 put data: "writer_id = 8 numMsg= 11" in position 2
Writer 2 put data: "writer_id = 2 numMsg= 11" in position 3
Writer 3 put data: "writer_id = 3 numMsg= 11" in position 4
Reader 5 get data: "writer_id = 0 numMsg= 11" from position 1
Reader 1 get data: "writer_id = 8 numMsg= 11" from position 2
Reader 8 get data: "writer_id = 2 numMsg= 11" from position 3
Writer 9 put data: "writer_id = 9 numMsg= 11" in position 5
Reader 2 get data: "writer_id = 3 numMsg= 11" from position 4
Writer 6 put data: "writer_id = 6 numMsg= 11" in position 6
Reader 6 get data: "writer_id = 9 numMsg= 11" from position 5
Reader 7 get data: "writer_id = 6 numMsg= 11" from position 6
Writer 1 put data: "writer_id = 1 numMsg= 11" in position 7
Writer 4 put data: "writer_id = 4 numMsg= 11" in position 8
Writer 7 put data: "writer_id = 7 numMsg= 11" in position 9
Writer 5 put data: "writer_id = 5 numMsg= 12" in position 0
Reader 3 get data: "writer_id = 1 numMsg= 11" from position 7
Writer 0 put data: "writer_id = 0 numMsg= 12" in position 1
Reader 9 get data: "writer_id = 4 numMsg= 11" from position 8
Reader 4 get data: "writer_id = 7 numMsg= 11" from position 9
Writer 8 put data: "writer_id = 8 numMsg= 12" in position 2
Writer 2 put data: "writer_id = 2 numMsg= 12" in position 3
Reader 0 get data: "writer_id = 5 numMsg= 12" from position 0
Writer 3 put data: "writer_id = 3 numMsg= 12" in position 4
Reader 8 get data: "writer_id = 0 numMsg= 12" from position 1
Reader 5 get data: "writer_id = 8 numMsg= 12" from position 2
Writer 6 put data: "writer_id = 6 numMsg= 12" in position 5
Reader 1 get data: "writer_id = 2 numMsg= 12" from position 3
Writer 9 put data: "writer_id = 9 numMsg= 12" in position 6
TimeManager finishing work
Reader 2 finishing work
Reader 7 finishing work
Reader 6 finishing work
Reader 3 finishing work
Reader 9 finishing work
Reader 4 finishing work
Reader 0 finishing work
Reader 5 finishing work
Reader 8 finishing work
Writer 7 finishing work
Writer 1 finishing work
Reader 1 finishing work
Writer 4 finishing work
Writer 5 finishing work
Writer 0 finishing work
Writer 8 finishing work
Writer 2 finishing work
Writer 3 finishing work
Writer 6 finishing work
Writer 9 finishing work
all is done
```

Рис. 2: Использование семафоров.

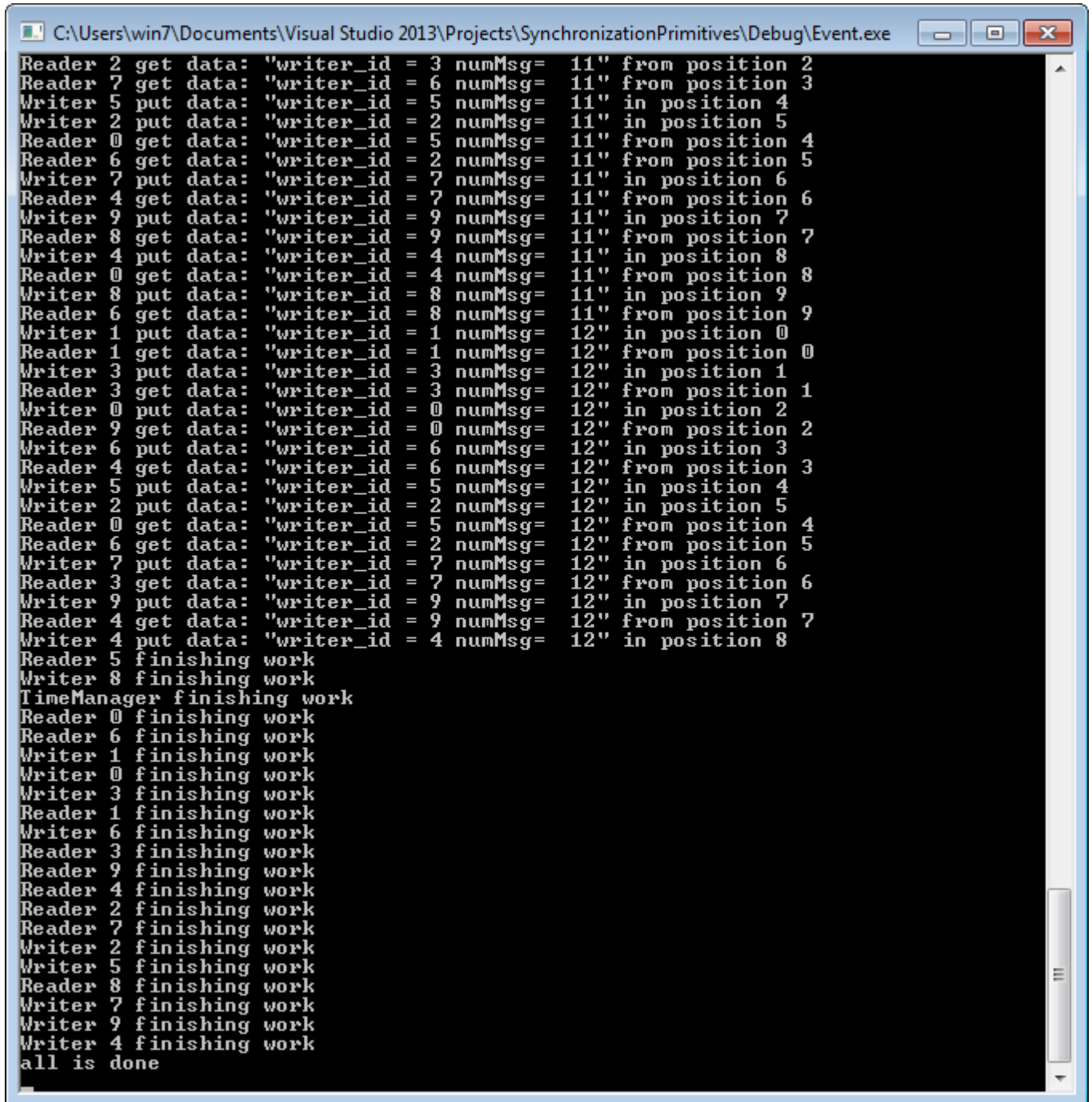
## 1.3 Критические секции



```
C:\Users\win7\Documents\Visual Studio 2013\Projects\SynchronizationPrimitives\Debug\CriticalSe...
Writer 7 put data: "writer_id = 7 numMsg= 12" in position 0
Reader 9 get data: "writer_id = 7 numMsg= 12" from position 0
Writer 8 put data: "writer_id = 8 numMsg= 12" in position 1
Reader 8 get data: "writer_id = 8 numMsg= 12" from position 1
Writer 3 put data: "writer_id = 3 numMsg= 12" in position 2
Reader 7 get data: "writer_id = 3 numMsg= 12" from position 2
Writer 2 put data: "writer_id = 2 numMsg= 12" in position 3
Writer 9 put data: "writer_id = 9 numMsg= 12" in position 4
Reader 3 get data: "writer_id = 2 numMsg= 12" from position 3
Reader 6 get data: "writer_id = 9 numMsg= 12" from position 4
Writer 4 put data: "writer_id = 4 numMsg= 12" in position 5
Reader 4 get data: "writer_id = 4 numMsg= 12" from position 5
Writer 5 put data: "writer_id = 5 numMsg= 12" in position 6
Writer 1 put data: "writer_id = 1 numMsg= 12" in position 7
Reader 8 get data: "writer_id = 5 numMsg= 12" from position 6
Reader 2 get data: "writer_id = 1 numMsg= 12" from position 7
Writer 6 put data: "writer_id = 6 numMsg= 12" in position 8
Reader 0 get data: "writer_id = 6 numMsg= 12" from position 8
Writer 0 put data: "writer_id = 0 numMsg= 12" in position 9
Reader 3 get data: "writer_id = 0 numMsg= 12" from position 9
Writer 7 put data: "writer_id = 7 numMsg= 13" in position 0
Writer 8 put data: "writer_id = 8 numMsg= 13" in position 1
Reader 9 get data: "writer_id = 7 numMsg= 13" from position 0
Reader 8 get data: "writer_id = 8 numMsg= 13" from position 1
Writer 3 put data: "writer_id = 3 numMsg= 13" in position 2
Reader 5 get data: "writer_id = 3 numMsg= 13" from position 2
Writer 2 put data: "writer_id = 2 numMsg= 13" in position 3
Reader 0 get data: "writer_id = 2 numMsg= 13" from position 3
Writer 9 put data: "writer_id = 9 numMsg= 13" in position 4
Reader 1 get data: "writer_id = 9 numMsg= 13" from position 4
Writer 4 put data: "writer_id = 4 numMsg= 13" in position 5
Reader 3 get data: "writer_id = 4 numMsg= 13" from position 5
Writer 5 put data: "writer_id = 5 numMsg= 13" in position 6
Writer 1 put data: "writer_id = 1 numMsg= 13" in position 7
Reader 9 get data: "writer_id = 5 numMsg= 13" from position 6
Reader 8 finishing work
TimeManager finishing work
Writer 6 finishing work
Reader 5 finishing work
Reader 2 finishing work
Reader 7 finishing work
Writer 0 finishing work
Reader 0 finishing work
Reader 1 finishing work
Writer 7 finishing work
Reader 3 finishing work
Writer 8 finishing work
Reader 6 finishing work
Reader 4 finishing work
Writer 3 finishing work
Reader 9 finishing work
Writer 2 finishing work
Writer 9 finishing work
Writer 4 finishing work
Writer 5 finishing work
Writer 1 finishing work
all is done
```

Рис. 3: Критические секции.

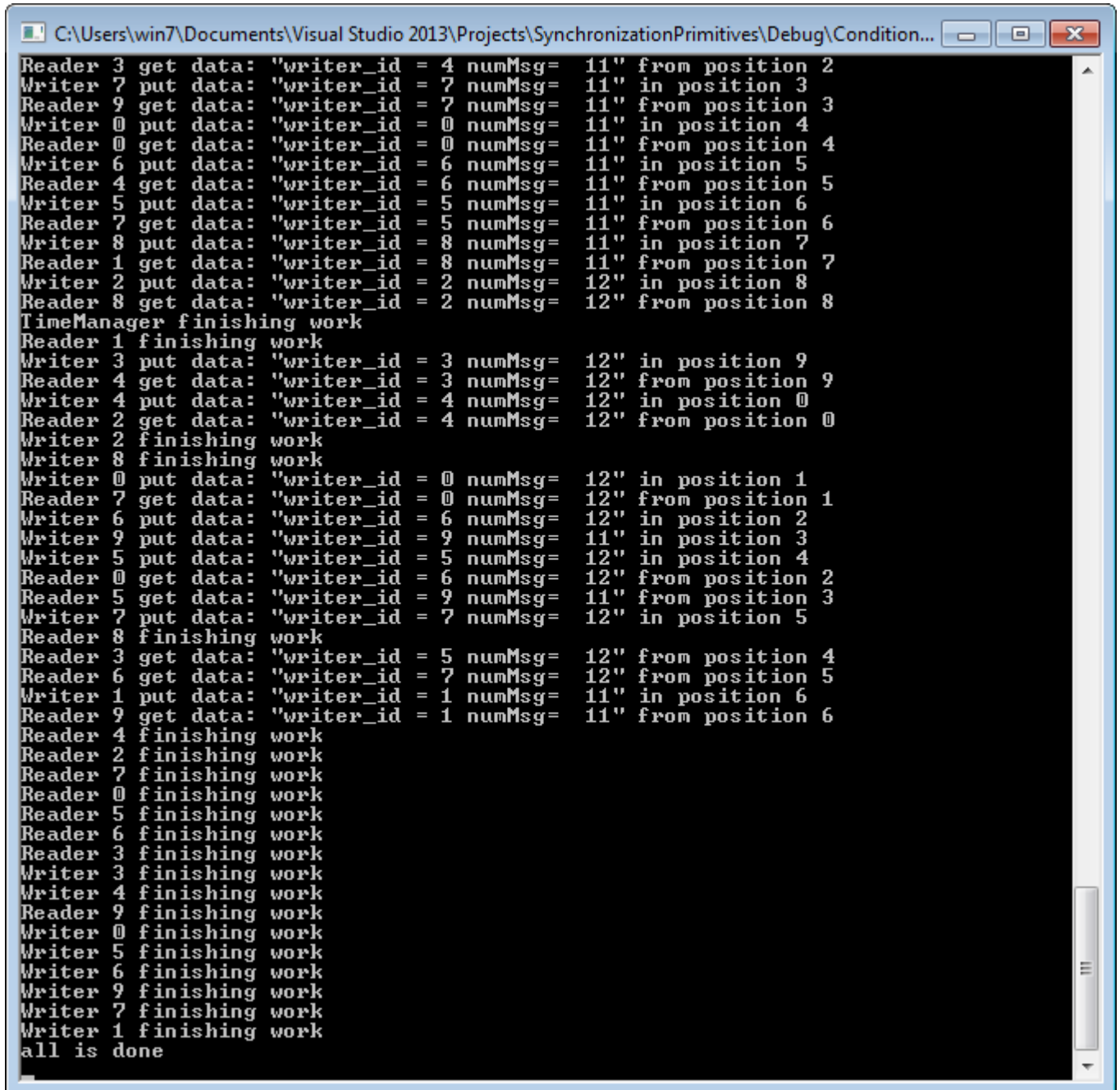
## 1.4 Объекты-события в качестве средства синхронизации



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

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

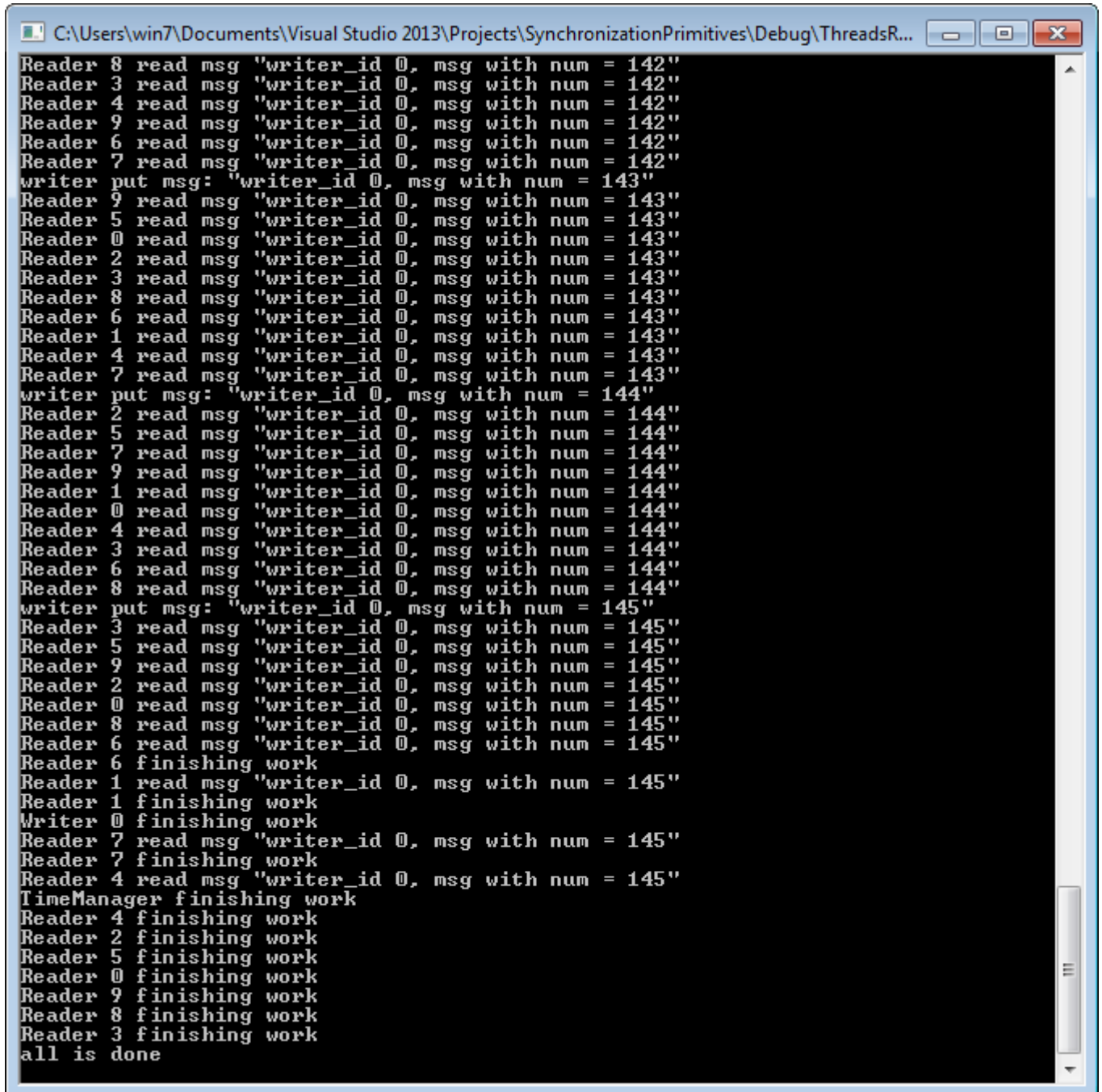
## 1.5 Условные переменные



```
Reader 3 get data: "writer_id = 4 numMsg= 11" from position 2
Writer 7 put data: "writer_id = 7 numMsg= 11" in position 3
Reader 9 get data: "writer_id = 7 numMsg= 11" from position 3
Writer 0 put data: "writer_id = 0 numMsg= 11" in position 4
Reader 0 get data: "writer_id = 0 numMsg= 11" from position 4
Writer 6 put data: "writer_id = 6 numMsg= 11" in position 5
Reader 4 get data: "writer_id = 6 numMsg= 11" from position 5
Writer 5 put data: "writer_id = 5 numMsg= 11" in position 6
Reader 7 get data: "writer_id = 5 numMsg= 11" from position 6
Writer 8 put data: "writer_id = 8 numMsg= 11" in position 7
Reader 1 get data: "writer_id = 8 numMsg= 11" from position 7
Writer 2 put data: "writer_id = 2 numMsg= 12" in position 8
Reader 8 get data: "writer_id = 2 numMsg= 12" from position 8
TimeManager finishing work
Reader 1 finishing work
Writer 3 put data: "writer_id = 3 numMsg= 12" in position 9
Reader 4 get data: "writer_id = 3 numMsg= 12" from position 9
Writer 4 put data: "writer_id = 4 numMsg= 12" in position 0
Reader 2 get data: "writer_id = 4 numMsg= 12" from position 0
Writer 2 finishing work
Writer 8 finishing work
Writer 0 put data: "writer_id = 0 numMsg= 12" in position 1
Reader 7 get data: "writer_id = 0 numMsg= 12" from position 1
Writer 6 put data: "writer_id = 6 numMsg= 12" in position 2
Writer 9 put data: "writer_id = 9 numMsg= 11" in position 3
Writer 5 put data: "writer_id = 5 numMsg= 12" in position 4
Reader 0 get data: "writer_id = 6 numMsg= 12" from position 2
Reader 5 get data: "writer_id = 9 numMsg= 11" from position 3
Writer 7 put data: "writer_id = 7 numMsg= 12" in position 5
Reader 8 finishing work
Reader 3 get data: "writer_id = 5 numMsg= 12" from position 4
Reader 6 get data: "writer_id = 7 numMsg= 12" from position 5
Writer 1 put data: "writer_id = 1 numMsg= 11" in position 6
Reader 9 get data: "writer_id = 1 numMsg= 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 3 finishing work
Writer 3 finishing work
Writer 4 finishing work
Reader 9 finishing work
Writer 0 finishing work
Writer 5 finishing work
Writer 6 finishing work
Writer 9 finishing work
Writer 7 finishing work
Writer 1 finishing work
all is done
```

Рис. 5: Условные переменные.

## 1.6 Задача читатели и писатели



```
C:\Users\win7\Documents\Visual Studio 2013\Projects\SynchronizationPrimitives\Debug\ThreadsR...
Reader 8 read msg "writer_id 0, msg with num = 142"
Reader 3 read msg "writer_id 0, msg with num = 142"
Reader 4 read msg "writer_id 0, msg with num = 142"
Reader 9 read msg "writer_id 0, msg with num = 142"
Reader 6 read msg "writer_id 0, msg with num = 142"
Reader 7 read msg "writer_id 0, msg with num = 142"
writer put msg: "writer_id 0, msg with num = 143"
Reader 9 read msg "writer_id 0, msg with num = 143"
Reader 5 read msg "writer_id 0, msg with num = 143"
Reader 0 read msg "writer_id 0, msg with num = 143"
Reader 2 read msg "writer_id 0, msg with num = 143"
Reader 3 read msg "writer_id 0, msg with num = 143"
Reader 8 read msg "writer_id 0, msg with num = 143"
Reader 6 read msg "writer_id 0, msg with num = 143"
Reader 1 read msg "writer_id 0, msg with num = 143"
Reader 4 read msg "writer_id 0, msg with num = 143"
Reader 7 read msg "writer_id 0, msg with num = 143"
writer put msg: "writer_id 0, msg with num = 144"
Reader 2 read msg "writer_id 0, msg with num = 144"
Reader 5 read msg "writer_id 0, msg with num = 144"
Reader 7 read msg "writer_id 0, msg with num = 144"
Reader 9 read msg "writer_id 0, msg with num = 144"
Reader 1 read msg "writer_id 0, msg with num = 144"
Reader 0 read msg "writer_id 0, msg with num = 144"
Reader 4 read msg "writer_id 0, msg with num = 144"
Reader 3 read msg "writer_id 0, msg with num = 144"
Reader 6 read msg "writer_id 0, msg with num = 144"
Reader 8 read msg "writer_id 0, msg with num = 144"
writer put msg: "writer_id 0, msg with num = 145"
Reader 3 read msg "writer_id 0, msg with num = 145"
Reader 5 read msg "writer_id 0, msg with num = 145"
Reader 9 read msg "writer_id 0, msg with num = 145"
Reader 2 read msg "writer_id 0, msg with num = 145"
Reader 0 read msg "writer_id 0, msg with num = 145"
Reader 8 read msg "writer_id 0, msg with num = 145"
Reader 6 read msg "writer_id 0, msg with num = 145"
Reader 6 finishing work
Reader 1 read msg "writer_id 0, msg with num = 145"
Reader 1 finishing work
Writer 0 finishing work
Reader 7 read msg "writer_id 0, msg with num = 145"
Reader 7 finishing work
Reader 4 read msg "writer_id 0, msg with num = 145"
TimeManager finishing work
Reader 4 finishing work
Reader 2 finishing work
Reader 5 finishing work
Reader 0 finishing work
Reader 9 finishing work
Reader 8 finishing work
Reader 3 finishing work
all is done
```

Рис. 6: Задача читатели и писатели.



## 1.7 Решение задачи читатели-писатели для потоков

```
readready= 4
Reader 9 read msg "writer_id 0, msg with num = 219"
readcount= 6
readready= 2
Reader 9 finishing work
all is done

readready= 1
Reader 1 read msg "writer_id 0, msg with num = 219"
readcount= 2
readready= 6
Reader 1 finishing work
all is done

readready= 3
Reader 7 read msg "writer_id 0, msg with num = 219"
readcount= 8
readready= 1
Reader 7 finishing work
all is done

readready= 9
Reader 8 read msg "writer_id 0, msg with num = 219"
readcount= 1
readready= 9
Reader 8 finishing work
all is done

Reader 3 read msg "writer_id 0, msg with num = 218"
readcount= 5
readready= 7
Reader 3 read msg "writer_id 0, msg with num = 219"
readcount= 3
readready= 8
Reader 3 finishing work
all is done

readcount= 7
readready= 6
Reader 2 read msg "writer_id 0, msg with num = 219"
readcount= 9
readready= 4
Reader 2 finishing work
all is done

readcount= 4
Reader 5 read msg "writer_id 0, msg with num = 219"
readready= 5
readcount= 7
readready= 7
Reader 5 finishing work
all is done

writer put msg: "writer_id 0, msg with num = 197"
writer put msg: "writer_id 0, msg with num = 198"
writer put msg: "writer_id 0, msg with num = 199"
writer put msg: "writer_id 0, msg with num = 200"
writer put msg: "writer_id 0, msg with num = 201"
writer put msg: "writer_id 0, msg with num = 202"
writer put msg: "writer_id 0, msg with num = 203"
writer put msg: "writer_id 0, msg with num = 204"
writer put msg: "writer_id 0, msg with num = 205"
writer put msg: "writer_id 0, msg with num = 206"
writer put msg: "writer_id 0, msg with num = 207"
writer put msg: "writer_id 0, msg with num = 208"
writer put msg: "writer_id 0, msg with num = 209"
writer put msg: "writer_id 0, msg with num = 210"
writer put msg: "writer_id 0, msg with num = 211"
writer put msg: "writer_id 0, msg with num = 212"
writer put msg: "writer_id 0, msg with num = 213"
writer put msg: "writer_id 0, msg with num = 214"
writer put msg: "writer_id 0, msg with num = 215"
writer put msg: "writer_id 0, msg with num = 216"
writer put msg: "writer_id 0, msg with num = 217"
writer put msg: "writer_id 0, msg with num = 218"
Writer 0 finishing work
TimeManager finishing work

readcount= 8
readready= 2
Reader 4 read msg "writer_id 0, msg with num = 219"
readcount= 4
readready= 3
Reader 4 finishing work
all is done

Reader 0 read msg "writer_id 0, msg with num = 218"
readcount= 0
readready= 5
Reader 0 read msg "writer_id 0, msg with num = 219"
readcount= 0
readready= 5
Reader 0 finishing work
all is done

readready= 2
readcount= 2
readready= 0
Reader 6 read msg "writer_id 0, msg with num = 219"
readcount= 7
readready= 0
Reader 6 finishing work
all is done
```

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

## 2 Модификация задачи читатели-писатели без доступа читателей на запись

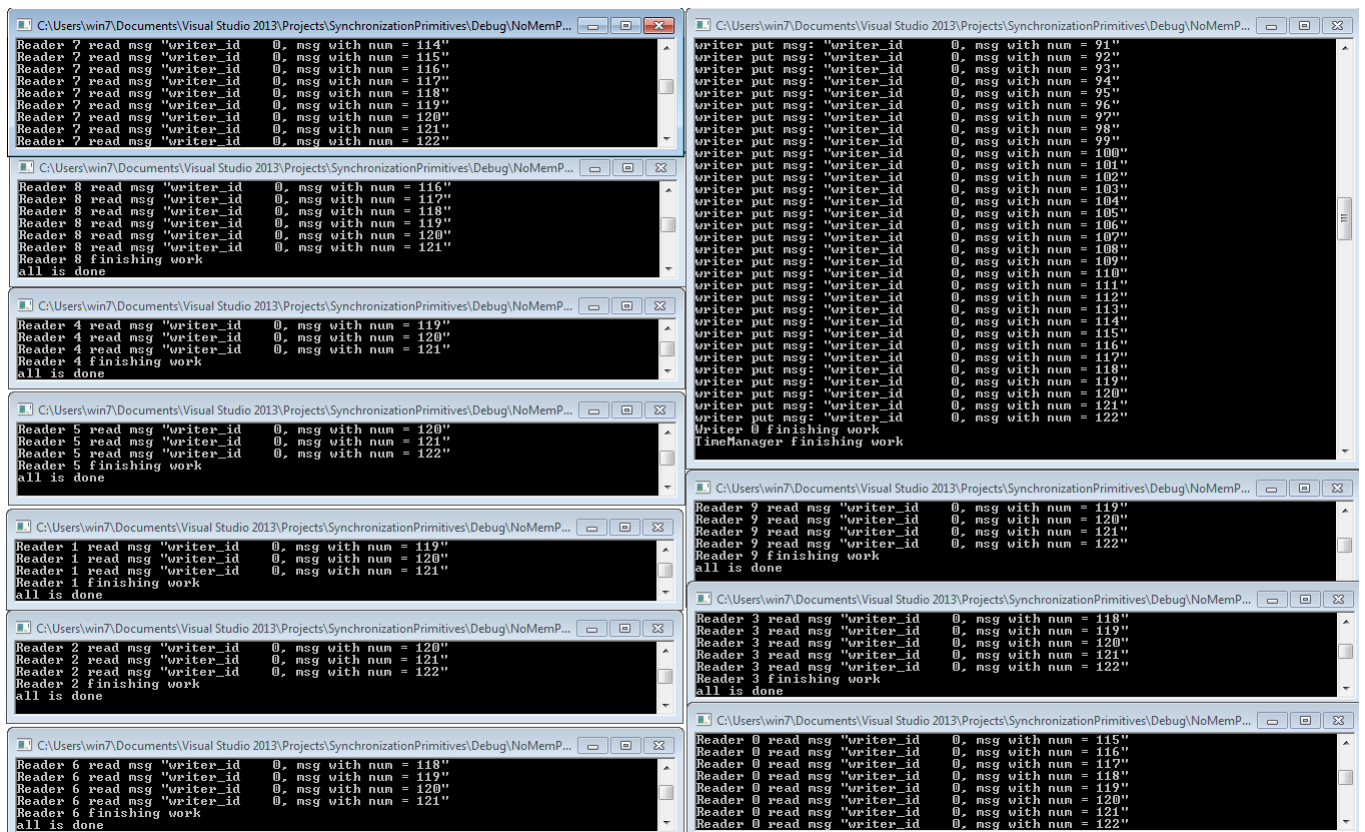


Рис. 8: Модификация задачи читатели-писатели.

## Выводы