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Προκειμένου να μεταγλωττιστεί και να τρέξει η εργασία:

- make && ./feeder M n , όπου M ο αριθμός των στοιχείων του πίνακα και n ο αριθμός των διεργασιών.
- make clean για να διαγραφθούν τα εκτελέσιμα και τα αρχεία που δημιούργησε η κάθε διεργασία

Λίγα λόγια για το πρόγραμμα:

Καταρχάς, τον κώδικα για την δημιουργία σεμαφόρων και την διαμοιραζόμενη μνήμη τον δανείστηκα από την πρώτη εργασία που κι εκεί είχε ζητηθεί κάτι παρόμοιο. Σκοπός του feeder ήταν να δημιουργήσει έναν πίνακα ακεραίων και να βάζει ένα-ένα στοιχείο του στην διαμοιραζόμενη μνήμη, να το παίρνουν οι n διεργασίες που θα δημιουργήσει και στο τέλος το parent process και τα child processes να έχουν τον ίδιο πίνακα. Για τον σκοπό αυτόν, δημιούργησα δύο πίνακες σεμαφόρων από n στοιχεία (semaphore_1[n], semaphore_2[n]) έτσι ώστε η κάθε διεργασία-παιδί να έχει τους δικούς της 2 σεμαφόρους που θα μπορεί να χειρίζεται και ο μπαμπας-διεργασία, αφού πλέον η αναφορά στον σημαφόρο πχ. semaphore_1[i] σημαίνει ότι πειράζουμε τον σεμαφόρο 1 της Ci διεργασίας. Η επιλογή αυτής της τακτικής έγινε αφενός για τον κατάλληλο συγχρονισμό των διεργασιών μεταξύ τους, αφετέρου διότι η επιλογή μόνο 2 σεμαφόρων (κι όχι πίνακα από n σεμαφόρους) θα καθυστερούσε πολύ την εκτέλεση του προγράμματος (από το μεγάλο busy waiting) παρ' ότι χρειάζονται λιγότεροι πόροι σε σχέση με την τακτική που διάλεξα.

Feeder.c:

Αρχικά, ο feeder αφού κάνει τους κατάλληλους ελέγχους για την εγκυρότητα του M, n, δημιουργεί ένα πίνακα από τυχαίους ακεραίους στο διάστημα [0,99] και δημιουργεί και αρχικοποιεί (σε 0) τους 2 πίνακες από n σεμαφόρους, καθώς και την διαμοιραζόμενη μνήμη. Στην συνέχεια, δημιουργεί με fork() n διεργασίες και χωρίζει τις εξής περιπτώσεις:

- Αν είμαστε στην περίπτωση του parent-process τότε αυτό που κάνει είναι κατ' επανάληψη να βάζει ένα στοιχείο του πίνακά του μαζί με την συγκεκριμένη ώρα που τό βαλε στην διαμοιραζόμενη μνήμη κι έπειτα να να “ανεβάξει” όλους τους σεμαφόρους_1 όλων των child-processes για να καταλάβουν ότι μόλις κάτι έχει μπει στην διαμοιραζόμενη μνήμη και πρέπει να το πάρουν. Ύστερα, για κάθε διεργασία “κατεβάζει” τον σεμαφόρο_2 τους και περιμένει μέχρι να τον “ανεβάσουν” όλες για να καταλάβει ότι όλες πήραν τον ακέραιο και να συνεχίσει να βάλει τον επόμενο. Αφού τελειώσει με όλα τα στοιχεία του πίνακα του, τότε απλά περιμένει να τελειώσουν όλα τα child processes για να αποδεσμεύσει την μνήμη που δέσμευσε και να τερματίσει.
- Αν είμαστε στην περίπτωση των child-processes, επαναληπτικά για τα M στοιχεία το κάθε παιδί “κατεβάζει” τον σεμαφόρο_1 της και παίρνει από την διαμοιραζόμενη μνήμη το στοιχείο που μόλις έβαλε το parent process και υπολογίζει την καθυστέρηση από την στιγμή που μπήκε στην μνήμη μέχρι την στιγμή που το συγκεκριμένο παιδί το ανάκτησε. Αθροίζει όλες τις καθυστερήσεις και αφού πάρει όλα τα στοιχεία του πίνακα υπολογίζει την μέση καθυστέρηση (σε ms). Κάθε φορά που παίρνει ένα στοιχείο μία διεργασία “ανεβάξει” τον σεμαφόρο_2 της για να καταλάβει το parent process ότι το πήρε. Τέλος, η κάθε διεργασία δημιουργεί έναν φάκελο με το id της σε μορφή fileid όπου μέσα έχει τον τελικό αντεγγραμμένο πίνακα και την μέση καθυστέρηση που έκανε για να τον ανακτήσει και τερματίζει.

Σημειώσεις:

- Το shared memory εμπεριέχει μόνο τον ακέραιο και την χρονική στιγμή που μπήκε εκείνος στην μνήμη.
- Οι 2 πίνακες από δυαδικούς σεμαφόρους είναι global ώστε να έχουν πρόσβαση σε αυτούς όλες οι διεργασίες.

Εδώ παραθέτω μερικά από τις εκτελέσεις που έτρεξα για $M=(3500, 10000)$ και $n=(5, 10, 100, 500, 1000)$:

```
(base) alexa@alexa-Inspiron-5579:~/Documents/OS/Ergasia_3$ ./feeder 3500 5
The average delay of process 4849 is 8 ms.
The average delay of process 4850 is 9 ms.
The average delay of process 4847 is 4 ms.
The average delay of process 4848 is 6 ms.
The average delay of process 4846 is 3 ms.
```

```
(base) alexa@alexa-Inspiron-5579:~/Documents/OS/Ergasia_3$ ./feeder 3500 10
The average delay of process 4880 is 4 ms.
The average delay of process 4879 is 3 ms.
The average delay of process 4881 is 6 ms.
The average delay of process 4882 is 8 ms.
The average delay of process 4884 is 12 ms.
The average delay of process 4883 is 10 ms.
The average delay of process 4885 is 14 ms.
The average delay of process 4887 is 18 ms.
The average delay of process 4886 is 16 ms.
The average delay of process 4888 is 21 ms.
```

```
(base) alexa@alexa-Inspiron-5579:~/Documents/OS/Ergasia_3$ ./feeder 3500 100
The average delay of process 4906 is 7 ms.
The average delay of process 4907 is 10 ms.
The average delay of process 4904 is 3 ms.
The average delay of process 4917 is 34 ms.
The average delay of process 4918 is 35 ms.
The average delay of process 4923 is 47 ms.
The average delay of process 4942 is 91 ms.
The average delay of process 4916 is 32 ms.
The average delay of process 4931 is 67 ms.
The average delay of process 4944 is 97 ms.
The average delay of process 4957 is 126 ms.
The average delay of process 4952 is 115 ms.
The average delay of process 4954 is 119 ms.
The average delay of process 4922 is 44 ms.
The average delay of process 4963 is 139 ms.
The average delay of process 4974 is 165 ms.
The average delay of process 4980 is 178 ms.
The average delay of process 4914 is 27 ms.
The average delay of process 4991 is 203 ms.
The average delay of process 4970 is 155 ms.
The average delay of process 4928 is 59 ms.
The average delay of process 4977 is 172 ms.
The average delay of process 4956 is 124 ms.
The average delay of process 4930 is 65 ms.
The average delay of process 4965 is 144 ms.
The average delay of process 4986 is 192 ms.
The average delay of process 4967 is 148 ms.
The average delay of process 4992 is 206 ms.
The average delay of process 4984 is 188 ms.
The average delay of process 4943 is 94 ms.
The average delay of process 4978 is 174 ms.
The average delay of process 4968 is 151 ms.
The average delay of process 4911 is 20 ms.
The average delay of process 4951 is 112 ms.
The average delay of process 4982 is 182 ms.
```

```
(base) alexa@alexa-Inspiron-5579:~/Documents/OS/Ergasia_3$ ./feeder 3500 500
```

```
The average delay of process 5509 is 34 ms.  
The average delay of process 5507 is 17 ms.  
The average delay of process 5512 is 48 ms.  
The average delay of process 5508 is 26 ms.  
The average delay of process 5510 is 36 ms.  
The average delay of process 5513 is 53 ms.  
The average delay of process 5586 is 579 ms.  
The average delay of process 5511 is 46 ms.  
The average delay of process 5566 is 436 ms.  
The average delay of process 5520 is 105 ms.  
The average delay of process 5596 is 651 ms.  
The average delay of process 5597 is 659 ms.  
The average delay of process 5523 is 129 ms.  
The average delay of process 5568 is 447 ms.  
The average delay of process 5604 is 705 ms.  
The average delay of process 5603 is 698 ms.  
The average delay of process 5537 is 230 ms.  
The average delay of process 5580 is 534 ms.  
The average delay of process 5515 is 68 ms.  
The average delay of process 5591 is 610 ms.  
The average delay of process 5607 is 728 ms.  
The average delay of process 5614 is 773 ms.  
The average delay of process 5581 is 545 ms.
```

```
The average delay of process 5609 is 2000 ms.  
The average delay of process 5846 is 2370 ms.  
The average delay of process 5901 is 2741 ms.  
The average delay of process 5943 is 3035 ms.  
The average delay of process 5881 is 2605 ms.  
The average delay of process 5874 is 2556 ms.  
The average delay of process 5584 is 576 ms.  
The average delay of process 5688 is 1287 ms.  
The average delay of process 5918 is 2860 ms.  
The average delay of process 5768 is 1840 ms.  
The average delay of process 5947 is 3060 ms.  
The average delay of process 5946 is 3055 ms.  
The average delay of process 5755 is 1749 ms.  
The average delay of process 5708 is 1424 ms.  
The average delay of process 5699 is 1364 ms.  
The average delay of process 5949 is 3075 ms.  
The average delay of process 5899 is 2730 ms.  
The average delay of process 5723 is 1529 ms.  
The average delay of process 5872 is 2543 ms.  
The average delay of process 5951 is 3089 ms.  
The average delay of process 5856 is 2436 ms.  
The average delay of process 5541 is 254 ms.
```

```
(base) alexa@alexa-Inspiron-5579:~/Documents/OS/Ergasia_3$ ./feeder 3500 1000
The average delay of process 6154 is 82 ms.
The average delay of process 6156 is 110 ms.
The average delay of process 6157 is 120 ms.
The average delay of process 6158 is 131 ms.
The average delay of process 6159 is 156 ms.
The average delay of process 6160 is 176 ms.
The average delay of process 6151 is 49 ms.
The average delay of process 6152 is 72 ms.
The average delay of process 6163 is 198 ms.
The average delay of process 6161 is 186 ms.
The average delay of process 6164 is 212 ms.
The average delay of process 6162 is 192 ms.
The average delay of process 6165 is 229 ms.
The average delay of process 6168 is 278 ms.
The average delay of process 6169 is 293 ms.
The average delay of process 6170 is 305 ms.
The average delay of process 6166 is 253 ms.
The average delay of process 6167 is 257 ms.
The average delay of process 6171 is 311 ms.
The average delay of process 6173 is 346 ms.
The average delay of process 6174 is 351 ms.
The average delay of process 6172 is 331 ms.
The average delay of process 6175 is 372 ms.
The average delay of process 6177 is 393 ms.
The average delay of process 6178 is 419 ms.
```

```
The average delay of process 7103 is 12911 ms.
The average delay of process 7105 is 12937 ms.
The average delay of process 7106 is 12951 ms.
The average delay of process 7107 is 12965 ms.
The average delay of process 7108 is 12978 ms.
The average delay of process 7109 is 12991 ms.
The average delay of process 7111 is 13019 ms.
The average delay of process 7112 is 13032 ms.
The average delay of process 7113 is 13047 ms.
The average delay of process 7115 is 13071 ms.
The average delay of process 7116 is 13085 ms.
The average delay of process 7117 is 13098 ms.
The average delay of process 7118 is 13113 ms.
The average delay of process 7119 is 13125 ms.
The average delay of process 7121 is 13152 ms.
The average delay of process 7120 is 13138 ms.
The average delay of process 7122 is 13165 ms.
The average delay of process 7123 is 13180 ms.
The average delay of process 7124 is 13191 ms.
The average delay of process 7125 is 13205 ms.
The average delay of process 7127 is 13234 ms.
The average delay of process 7126 is 13220 ms.
The average delay of process 7098 is 12845 ms.
The average delay of process 7129 is 13261 ms.
```



```
(base) alexa@alexa-Inspiron-5579:~/Documents/OS/Ergasia_3$ ./feeder 10000 5
The average delay of process 7272 is 3 ms.
The average delay of process 7276 is 10 ms.
The average delay of process 7274 is 6 ms.
The average delay of process 7275 is 8 ms.
The average delay of process 7273 is 4 ms.
```

```
(base) alexa@alexa-Inspiron-5579:~/Documents/OS/Ergasia_3$ ./feeder 10000 10
The average delay of process 7286 is 5 ms.
The average delay of process 7289 is 10 ms.
The average delay of process 7285 is 4 ms.
The average delay of process 7290 is 12 ms.
The average delay of process 7284 is 2 ms.
The average delay of process 7291 is 14 ms.
The average delay of process 7292 is 16 ms.
The average delay of process 7287 is 7 ms.
The average delay of process 7288 is 9 ms.
The average delay of process 7293 is 17 ms.
```

```
(base) alexa@alexa-Inspiron-5579:~/Documents/OS/Ergasia_3$ ./feeder 10000 100
The average delay of process 7997 is 8 ms.
The average delay of process 8054 is 138 ms.
The average delay of process 8001 is 17 ms.
The average delay of process 8055 is 140 ms.
The average delay of process 8019 is 57 ms.
The average delay of process 8031 is 84 ms.
The average delay of process 8063 is 157 ms.
The average delay of process 8000 is 14 ms.
The average delay of process 7998 is 10 ms.
The average delay of process 8005 is 26 ms.
The average delay of process 8007 is 30 ms.
The average delay of process 8015 is 48 ms.
The average delay of process 8029 is 80 ms.
The average delay of process 8008 is 32 ms.
The average delay of process 8073 is 180 ms.
The average delay of process 8060 is 151 ms.
The average delay of process 8026 is 73 ms.
The average delay of process 8090 is 217 ms.
The average delay of process 8079 is 192 ms.
The average delay of process 8040 is 105 ms.
The average delay of process 8046 is 118 ms.
The average delay of process 8051 is 130 ms.
The average delay of process 8093 is 224 ms.
The average delay of process 8058 is 147 ms.
The average delay of process 8064 is 160 ms.
The average delay of process 8003 is 21 ms.
The average delay of process 8009 is 34 ms.
The average delay of process 8022 is 64 ms.
The average delay of process 8056 is 143 ms.
The average delay of process 8006 is 28 ms.
The average delay of process 8094 is 226 ms.
The average delay of process 8076 is 186 ms.
The average delay of process 7996 is 5 ms.
The average delay of process 8011 is 40 ms.
```

```
(base) alexa@alexa-Inspiron-5579:~/Documents/OS/Ergasia_3$ ./feeder 10000 500
The average delay of process 8115 is 14 ms.
The average delay of process 8117 is 38 ms.
The average delay of process 8118 is 41 ms.
The average delay of process 8119 is 44 ms.
The average delay of process 8120 is 52 ms.
The average delay of process 8121 is 56 ms.
The average delay of process 8129 is 117 ms.
The average delay of process 8127 is 102 ms.
The average delay of process 8125 is 89 ms.
The average delay of process 8128 is 113 ms.
The average delay of process 8122 is 63 ms.
The average delay of process 8132 is 139 ms.
The average delay of process 8133 is 149 ms.
The average delay of process 8130 is 127 ms.
The average delay of process 8135 is 164 ms.
The average delay of process 8137 is 177 ms.
The average delay of process 8124 is 79 ms.
The average delay of process 8141 is 212 ms.
The average delay of process 8123 is 70 ms.
The average delay of process 8143 is 222 ms.
The average delay of process 8144 is 225 ms.
The average delay of process 8126 is 95 ms.
The average delay of process 8138 is 185 ms.
The average delay of process 8142 is 217 ms.
The average delay of process 8150 is 280 ms.
The average delay of process 8131 is 138 ms.
The average delay of process 8151 is 282 ms.
The average delay of process 8140 is 196 ms.
The average delay of process 8155 is 309 ms.
The average delay of process 8134 is 152 ms.
The average delay of process 8157 is 323 ms.
```

```
The average delay of process 8253 is 1018 ms.
The average delay of process 8225 is 819 ms.
The average delay of process 8255 is 1032 ms.
The average delay of process 8166 is 389 ms.
The average delay of process 8175 is 458 ms.
The average delay of process 8191 is 572 ms.
The average delay of process 8242 is 939 ms.
The average delay of process 8257 is 1046 ms.
The average delay of process 8258 is 1054 ms.
The average delay of process 8216 is 752 ms.
The average delay of process 8260 is 1068 ms.
The average delay of process 8262 is 1084 ms.
The average delay of process 8259 is 1063 ms.
The average delay of process 8264 is 1098 ms.
The average delay of process 8263 is 1090 ms.
The average delay of process 8266 is 1111 ms.
The average delay of process 8268 is 1125 ms.
The average delay of process 8261 is 1076 ms.
The average delay of process 8269 is 1134 ms.
The average delay of process 8265 is 1104 ms.
The average delay of process 8270 is 1141 ms.
The average delay of process 8272 is 1155 ms.
The average delay of process 8274 is 1168 ms.
The average delay of process 8273 is 1160 ms.
The average delay of process 8275 is 1175 ms.
The average delay of process 8276 is 1183 ms.
```

```
(base) alexa@alexa-Inspiron-5579:~/Documents/OS/Ergasia_3$ ./feeder 10000 1000
The average delay of process 8635 is 50 ms.
The average delay of process 8642 is 139 ms.
The average delay of process 8643 is 159 ms.
The average delay of process 8644 is 156 ms.
The average delay of process 8647 is 192 ms.
The average delay of process 8645 is 174 ms.
The average delay of process 8648 is 223 ms.
The average delay of process 8653 is 287 ms.
The average delay of process 8662 is 402 ms.
The average delay of process 8664 is 439 ms.
The average delay of process 8666 is 462 ms.
The average delay of process 8659 is 377 ms.
The average delay of process 8675 is 586 ms.
The average delay of process 8682 is 697 ms.
The average delay of process 8684 is 714 ms.
The average delay of process 8661 is 393 ms.
The average delay of process 8636 is 71 ms.
The average delay of process 8971 is 4550 ms.
The average delay of process 8970 is 4537 ms.
The average delay of process 8972 is 4564 ms.
The average delay of process 8639 is 79 ms.
The average delay of process 8973 is 4575 ms.
The average delay of process 8638 is 80 ms.
The average delay of process 8641 is 112 ms.
The average delay of process 8932 is 4026 ms.
The average delay of process 8974 is 4591 ms.
The average delay of process 8640 is 103 ms.
The average delay of process 8637 is 79 ms.
```

```
The average delay of process 8731 is 1335 ms.
The average delay of process 9541 is 12123 ms.
The average delay of process 9543 is 12149 ms.
The average delay of process 8785 is 2062 ms.
The average delay of process 9540 is 12109 ms.
The average delay of process 8772 is 1887 ms.
The average delay of process 8883 is 3374 ms.
The average delay of process 8782 is 2024 ms.
The average delay of process 8733 is 1362 ms.
The average delay of process 8757 is 1688 ms.
The average delay of process 8778 is 1968 ms.
The average delay of process 8885 is 3400 ms.
The average delay of process 8776 is 1942 ms.
The average delay of process 8784 is 2048 ms.
The average delay of process 8768 is 1835 ms.
The average delay of process 8888 is 3442 ms.
The average delay of process 8763 is 1769 ms.
The average delay of process 8889 is 3454 ms.
The average delay of process 8759 is 1715 ms.
The average delay of process 9545 is 12178 ms.
The average delay of process 9546 is 12190 ms.
The average delay of process 8788 is 2102 ms.
The average delay of process 9544 is 12164 ms.
The average delay of process 9547 is 12205 ms.
The average delay of process 9548 is 12216 ms.
The average delay of process 8730 is 1320 ms.
The average delay of process 8752 is 1620 ms.
```

```
The average delay of process 9609 is 13025 ms.
The average delay of process 9610 is 13039 ms.
The average delay of process 9611 is 13053 ms.
The average delay of process 9612 is 13065 ms.
The average delay of process 9613 is 13078 ms.
The average delay of process 9614 is 13090 ms.
The average delay of process 9615 is 13104 ms.
The average delay of process 9616 is 13116 ms.
The average delay of process 9617 is 13129 ms.
The average delay of process 9618 is 13143 ms.
The average delay of process 9619 is 13157 ms.
The average delay of process 9620 is 13170 ms.
The average delay of process 9621 is 13183 ms.
The average delay of process 9622 is 13195 ms.
The average delay of process 9623 is 13209 ms.
The average delay of process 9624 is 13223 ms.
The average delay of process 9625 is 13236 ms.
The average delay of process 9626 is 13248 ms.
The average delay of process 9627 is 13260 ms.
The average delay of process 9628 is 13275 ms.
The average delay of process 9629 is 13289 ms.
```

Παρατηρήσεις:

- Αρχικά, παρατηρούμε πως καθώς αυξάνεται ο αριθμός διεργασιών και το μέγεθος του πίνακα παραμένει σταθερό, η μέση καθυστέρηση αυξάνεται. Αυτό θα μπορούσαμε να πούμε ότι ήταν αναμενόμενο, αφού ο feeder όσο αυξάνεται ο αριθμός των διεργασιών τόσο περισσότερους σεμαφόρους πρέπει να ξεμπλοκάρει και να περιμένει άλλους τόσους για να ξεμπλοκάρει για να βάλει το επόμενο στοιχείο.
- Επίσης, παρατηρούμε σε όλες τις εκτελέσεις ότι κάποιες διεργασίες έχουν πολύ μικρό χρόνο καθυστέρησης σε σύγκριση με κάποιες άλλες που έχουν πολύ μεγαλύτερο. Αυτή η μεγάλη απόκλιση οφείλεται στο γεγονός ότι οι διεργασίες που φτιάχνονται πρώτες (και παίρνουν τις πρώτες θέσεις στους πίνακες των σεμαφόρων) θα 'ναι αυτές που θα τους ξεμπλοκάρει πρώτους το parent-process και θα πάρουν σχετικά νωρίς τον ακέραιο από την διαμοιραζόμενη μνήμη. Αντιθέτως, οι διεργασίες που δημιουργούνται τελευταίες (και άρα καταλαμβάνουν τις τελευταίες θέσεις στους πίνακες των σεμαφόρων) αργούν από τον feeder να ξεμπλοκαριστούν και γι αυτό έχουν πολύ μεγαλύτερη μέση καθυστέρηση.