Filas de Prioridade

Estruturas de Dados e Algoritmos – Ciência da Computação

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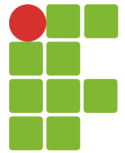

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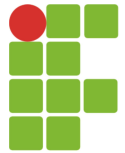

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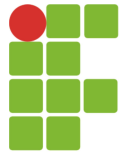
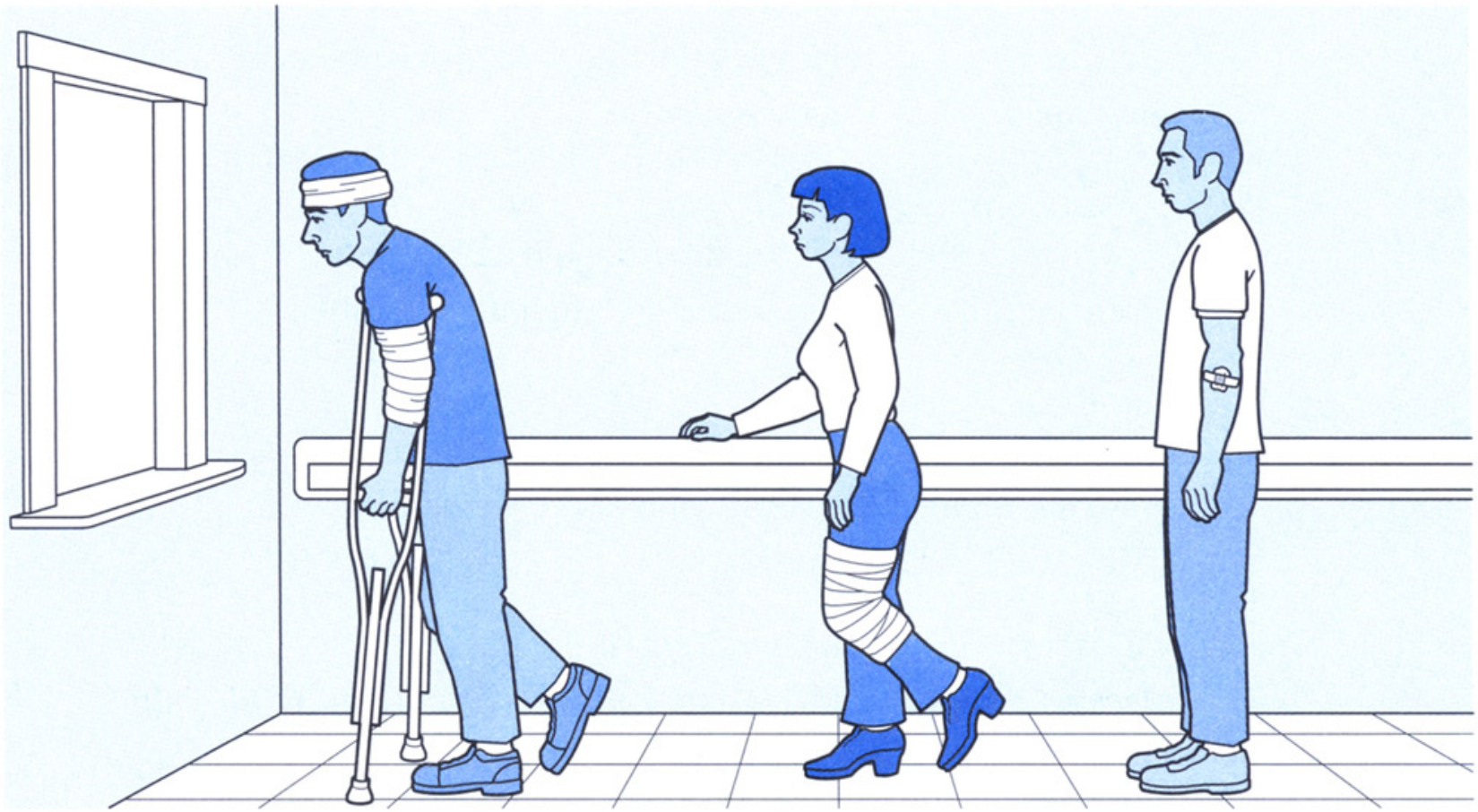
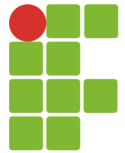


Filas de Prioridade

- Filas de prioridade são TADs que também generalizam filas.
- Neste TAD, cada elemento tem sua prioridade.
- Os elementos com maior prioridade tem precedência sobre o menor, e portanto são retirados primeiro, independente da ordem de inserção.
- Vocês já viram isso na vida real?

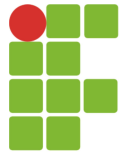
Filas de Prioridade





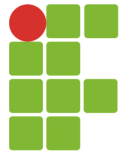
Operações em Filas de Prioridade

- Algumas das operações suportadas por uma fila devem ser:
  - Enfileiramento de elementos;
  - Desenfileiramento de elementos com maior prioridade;
  - Verificar o elemento com maior prioridade;



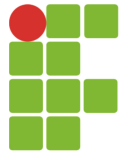
Operações em Filas de Prioridade

- Conhecemos alguma estrutura que realiza estas operações eficientemente?



Operações em Filas de Prioridade

- Sim, uma **heap**!
- Mas temos que adaptá-la em sua versão dinâmica.
- Temos que usar vetores dinâmicos.



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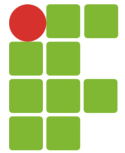

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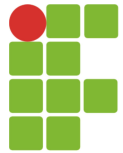
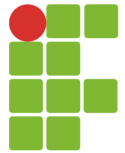


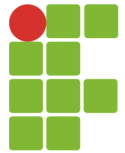
Filas de Prioridade: Definição

```
7  typedef void* (*priority_queue_element_constructor_fn) (void*);
8  typedef void (*priority_queue_element_destructor_fn)(void *);
9  typedef int (*priority_queue_element_compare_fn)(const void*,const void*);
```



Filas de Prioridade: Definição

```
12 typedef struct priority_queue_t{
13     void** data;
14     priority_queue_element_constructor_fn constructor;
15     priority_queue_element_destructor_fn destructor;
16     priority_queue_element_compare_fn comparator;
17     size_t size;
18     size_t capacity;
19 }priority_queue_t;
```



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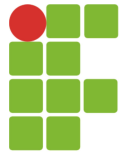
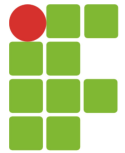


Filas de Prioridade: Inicialização

```
42  void priority_queue_initialize(priority_queue_t** pq,
43                                 priority_queue_element_constructor_fn constructor,
44                                 priority_queue_element_destructor_fn destructor,
45                                 priority_queue_element_compare_fn comparator){
46      (*pq) = mallocx(sizeof(priority_queue_t));
47      (*pq)->data = NULL;
48      (*pq)->constructor = constructor;
49      (*pq)->destructor = destructor;
50      (*pq)->comparator = comparator;
51      (*pq)->size = 0;
52      (*pq)->capacity = 0;
53  }
```



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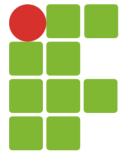
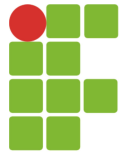


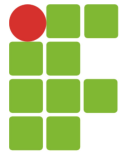
Filas de Prioridade: Inserção

```
97  size_t priority_queue_size(priority_queue_t* pq){
98      return pq->size;
99  }
```



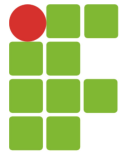
Filas de Prioridade: Inserção

```
101 size_t priority_queue_empty(priority_queue_t* pq){
102     return priority_queue_size(pq) == 0 ? 1: 0;
103 }
```



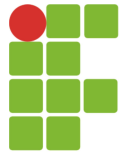
Filas de Prioridade: Funções Auxiliares

```
6  static void priority_queue_heapify_bottom_up(priority_queue_t* pq,size_t i){
7      size_t p;
8      for(p=(i-1)/2;i!=0;p=(p-1)/2){
9          if(pq->comparator(pq->data[i],pq->data[p])<=0){
10             break;
11         }
12         void* aux = pq->data[i];
13         pq->data[i] = pq->data[p];
14         pq->data[p] = aux;
15         i = p;
16     }
17 }
```



Filas de Prioridade: Funções Auxiliares

```
20  static void priority_queue_heapify_top_down(priority_queue_t* pq,size_t i){
21      size_t l,r;
22      size_t largest = i;
23      while(i<priority_queue_size(pq)){
24          i = largest;
25          l = 2*i +1;
26          r = 2*i +2;
27          if(l<priority_queue_size(pq) && pq->comparator(pq->data[i],pq->data[l])<=0){
28              largest = l;
29          }
30          if(r<priority_queue_size(pq) && pq->comparator(pq->data[largest],pq->data[r])<0){
31              largest = r;
32          }
33          if(largest==i){
34              break;
35          }
36          void* aux = pq->data[i];
37          pq->data[i] = pq->data[largest];
38          pq->data[largest] = aux;
39      }
40  }
```



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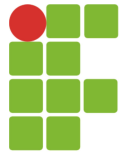
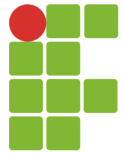


Filas de Prioridade: Inserção

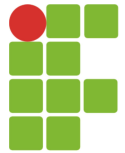
Inserção em Heap Dinâmica

- A inserção de um novo elemento é feito no final do vetor.
- Se o vetor não apresenta espaço suficiente, ele deverá ser relocado.
- A propriedade de Heap deve ser restaurada usando comparações debaixo para cima (bottom-up).
- O tamanho do vetor dinâmico aumenta de um.



Filas de Prioridade: Inserção

```
63 void priority_queue_push(priority_queue_t* pq,void* data){
64     if(pq->size == pq->capacity){
65         if(pq->capacity == 0){
66             pq->capacity = 1;
67         }
68         else{
69             pq->capacity*=2;
70         }
71         pq->data = reallocx(pq->data,pq->capacity * sizeof(void*));
72     }
73     pq->data[pq->size] = pq->constructor(data);
74     priority_queue_heapify_bottom_up(pq,pq->size);
75     pq->size++;
76 }
```



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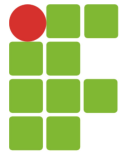
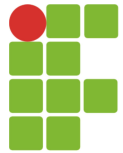


Filas de Prioridade: Acesso

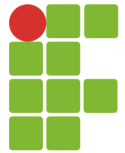
Consulta do Elemento de Maior Prioridade em Heap Dinâmica

- Pela propriedade de Heap, o elemento com maior prioridade ocupa a posição 0.
- Basta acessá-lo.



Filas de Prioridade: Inserção

```
78  void* priority_queue_front(priority_queue_t* pq){
79      assert(!priority_queue_empty(pq));
80      return(pq->data[0]);
81  }
```



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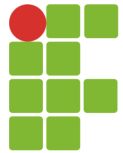
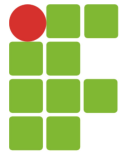


Operações em Filas de Prioridade

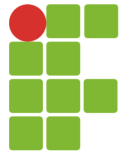
Remoção em Heap Dinâmica

- Pela propriedade de Heap, o elemento de maior prioridade ocupa a posição 0.
- A retirada é simulada ao colocar o elemento que ocupa a última posição do vetor na posição 0.
- A propriedade de heap deve ser restaurada ao utilizar comparações de cima para baixo (top-down).
- O tamanho do vetor dinâmico diminui de um.
- Se o tamanho for muito pequeno em comparação à área ocupada, o vetor dinâmico deverá ser relocado.



Filas de Prioridade: Remoção

```
83  void priority_queue_pop(priority_queue_t* pq){
84      assert(!priority_queue_empty(pq));
85      pq->size--;
86      pq->destructor(pq->data[0]);
87      if(!priority_queue_empty(pq)){
88          pq->data[0] = pq->data[pq->size];
89          priority_queue_heapify_top_down(pq,0);
90      }
91      if(pq->size == pq->capacity/2){
92          pq->data = reallocx(pq->data,pq->capacity/2 * sizeof(void*));
93          pq->capacity = pq->capacity/2;
94      }
95  }
```



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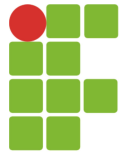
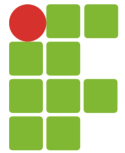


Filas de Prioridade: Limpeza

```
55 void priority_queue_delete(priority_queue_t** pq){
56     while(!priority_queue_empty(*pq)){
57         priority_queue_pop(*pq);
58     }
59     free(*pq);
60     *pq = NULL;
61 }
```



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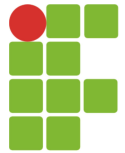
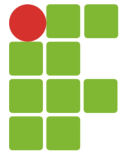


Operações em Filas de Prioridade

Operação	Complexidade
Consulta do elemento de maior prioridade	$\Theta(1)$
Remoção do elemento de maior prioridade	$\Theta(\lg n)$
Inserção de um novo elemento	$\Theta(\lg n)$



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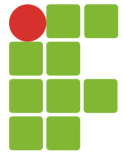
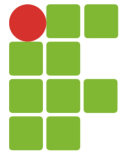


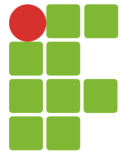
Exemplo de Uso da Biblioteca

```
8  typedef struct aluno{
9      char nome[50];
10     double p1,p2,p3;
11 } aluno;
```



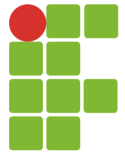
Exemplo de Uso da Biblioteca

```
13 void* aluno_constructor(void* data){
14     void* ptr = mallocx(sizeof(aluno));
15     memcpy(ptr,data,sizeof(aluno));
16     return ptr;
17 }
```



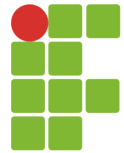
Exemplo de Uso da Biblioteca

```
19 void aluno_destructor(void* data){
20     free(data);
21 }
```



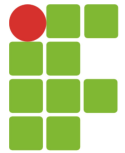
Exemplo de Uso da Biblioteca

```
23  int aluno_comparator(const void* a,const void* b){
24      aluno *aluno1, *aluno2;
25      aluno1 = a;
26      aluno2 = b;
27      double media1,media2;
28      media1 = (aluno1->p1 + aluno1->p2 + aluno1->p3)/3.0;
29      media2 = (aluno2->p1 + aluno2->p2 + aluno2->p3)/3.0;
30      if(media1<media2){
31          return -1;
32      }
33      else if(media1>media2){
34          return 1;
35      }
36      if(strcmp(aluno1->nome,aluno2->nome) < 0){
37          return 1;
38      }
39      else if(strcmp(aluno1->nome,aluno2->nome) > 0){
40          return -1;
41      }
42      return 0;
43  }
```



Exemplo de Uso da Biblioteca

```
47  int main(void){
48      aluno a;
49      aluno* aluno_ptr;
50      int nro_alunos = 4;
51      int i;
52      priority_queue_t* pq;
53      priority_queue_initialize(&pq,aluno_constructor,aluno_destructor,aluno_comparator);
54      for(i=1;i<=nro_alunos;i++){
55          printf("Aluno %d\n",i);
56          printf("Nome: ");
57          scanf("%s",a.nome);
58          printf("Nota P1: ");
59          scanf("%lf",&a.p1);
60          printf("Nota P2" );
61          scanf("%lf",&a.p2);
62          printf("Nota P3: ");
63          scanf("%lf",&a.p3);
64          priority_queue_push(pq,&a);
65      }
66
67      printf("\n\n");
```



Exemplo de Uso da Biblioteca

```
69      while(!priority_queue_empty(pq)){
70          aluno_ptr = priority_queue_front(pq);
71          printf("Nome: %s\n",aluno_ptr->nome);
72          printf("P1: %lf\n",aluno_ptr->p1);
73          printf("P2: %lf\n",aluno_ptr->p2);
74          printf("P3: %lf\n",aluno_ptr->p3);
75          priority_queue_pop(pq);
76      }
77      priority_queue_delete(&pq);
78      return 0;
79  }
```