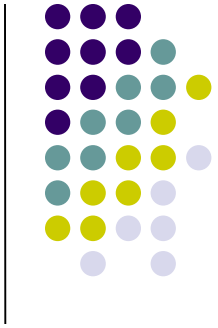
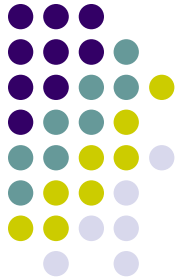


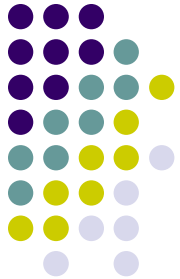
Посебни елементи физичке архитектуре и њихово искоришћење из Цеа

Груписање процесора по намени



- Процесори опште намене
- Наменски процесори (Процесори посебне намене)
  - **ДСП-ови**
  - Микроконтролери
  - Графички процесори...

Илустрација уобичајене конструкције у ДОС



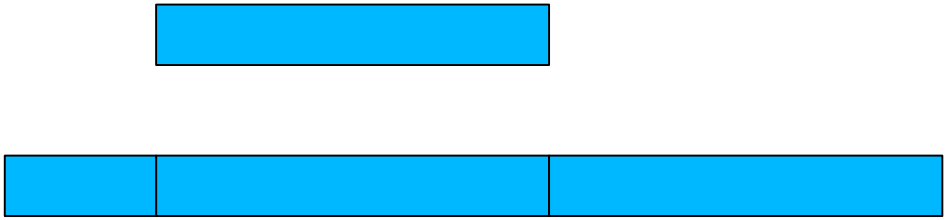
```
float aryA[N];
float aryB[N];
float aryC[N];

void conv() {
  int i;
  for (i = 0; i < N; ++i) {
    aryC[i] = aryA[i] * aryB[i];
  }
}
```

Аритметика у непокретном зарезу

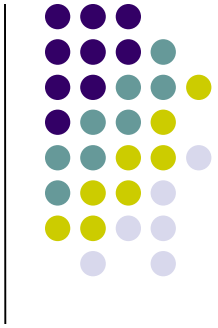
```
1.000 (-1)   int a = 0x8; //1000    _Fract a = -1.0r;
0.011 (3/8)  int b = 0x3; //0011    _Fract b = 0.375r;

11.101000    int c = fp_mul(a, b); _Fract c = a * b;
     << 1
1.101000
```

```
_Fract
long _Fract
_Accum
long _Accum

0.25r, 0.5lr, 5.6k, 50.7lk, 1.5r
```

Акумулатори



```
0.5 + 0.75 - 0.3 - 0.8 - 0.6 - 0.4 - 0.25 + 0.5 = -0.6

0.5 + 0.75 = 1.25
0.5 + 0.75 - 0.3 = 0.95
0.5 + 0.75 - 0.3 - 0.8 = 0.15
0.5 + 0.75 - 0.3 - 0.8 - 0.6 = -0.45
0.5 + 0.75 - 0.3 - 0.8 - 0.6 - 0.4 = -0.85
0.5 + 0.75 - 0.3 - 0.8 - 0.6 - 0.4 - 0.25 = -1.1
0.5 + 0.75 - 0.3 - 0.8 - 0.6 - 0.4 - 0.25 + 0.5 = -0.6
```



```
float aryA[N];
float aryB[N];
float aryC[N];

void conv() {
  int i;
  for (i = 0; i < N; ++i) {
    aryC[i] = aryA[i] * aryB[i];
  }
}
```

```
_Fract aryA[N];
_Fract aryB[N];
_Fract aryC[N];

void conv() {
  int i;
  for (i = 0; i < N; ++i) {
    aryC[i] = aryA[i] * aryB[i];
  }
}
```

```
_conv:
  a1 = 0
start:
  a1 > 30
  if (T) jmp end:
    i0 = _aryA + a1
    x0 = mem[i0]
    i0 = _aryB + a1
    y0 = mem[i0]
    a0 = x0 * y0
    i0 = _aryC + a1
    mem[i0] = a0
    a1 = a1 + 1
    jmp start
end:
    i7 = mem[i6]
    jmp i7
```

Адресни генератор

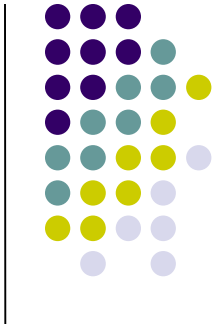
```
...ary[0];
...ary[2];
...ary[1];
...ary[2];
...ary[3];
```

```
p = ary;
...*p; p+=2
...*p--;
...*p++;
...*p++;
...*p;
```

```
struct s
{
  int a;
  int b;
  int c;
  int d;
};
```

```
struct s* ps;

...ps->d;
...ps->a;
...ps->c;
...ps->b;
```

```
struct s
{
  int d;
  int a;
  int c;
  int b;
};
```

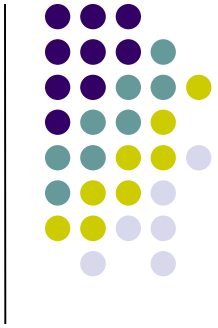


```
_Fract aryA[N];
_Fract aryB[N];
_Fract aryC[N];

void conv() {
  int i;
  for (i = 0; i < N; ++i) {
    aryC[i] = aryA[i] * aryB[i];
  }
}
```

```
void conv() {
  int i;
  _Fract* pA = &aryA[0];
  _Fract* pB = &aryB[0];
  _Fract* pC = &aryC[0];
  for (i = 0; i < N; ++i) {
    *pC++ = *pA++ * *pB++;
  }
}
```

```
_conv:
  a1 = 0
start:
  a1 > 30
  if (T) jmp end:
    i0 = _aryA + a1
    x0 = mem[i0]
    i0 = _aryB + a1
    y0 = mem[i0]
    a0 = x0 * y0
    i0 = _aryC + a1
    mem[i0] = a0
    a1 = a1 + 1
    jmp start
end:
    i7 = mem[i6]
    jmp i7
```

```
_conv:
  a1 = 0
start:
  a1 > 30
  if (T) jmp end:
    x0 = mem[i0]
    i0 = i0 + 1
    y0 = mem[i4]
    i4 = i4 + 1
    a0 = x0 * y0
    mem[i1] = a0
    i1 = i1 + 1
    a1 = a1 + 1
    jmp start
end:
    i7 = mem[i6]
    jmp i7
```



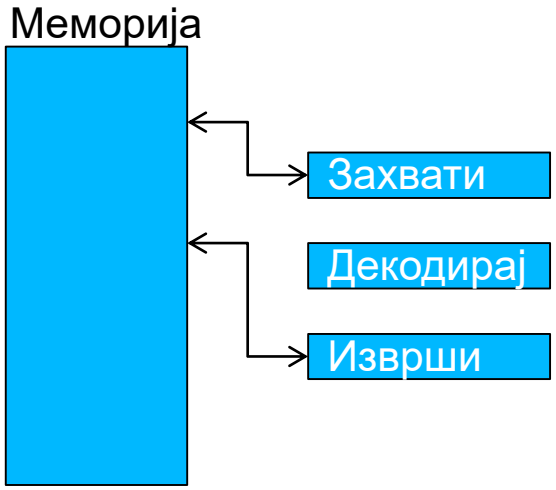
```
_Fract aryA[N];
_Fract aryB[N];
_Fract aryC[N];

void conv() {
  int i;
  for (i = 0; i < N; ++i) {
    aryC[i] = aryA[i] * aryB[i];
  }
}
```

```
void conv() {
  int i;
  _Fract* pA = &aryA[0];
  _Fract* pB = &aryB[0];
  _Fract* pC = &aryC[0];
  for (i = 0; i < N; ++i) {
    *pC++ = *pA++ * *pB++;
  }
}
```

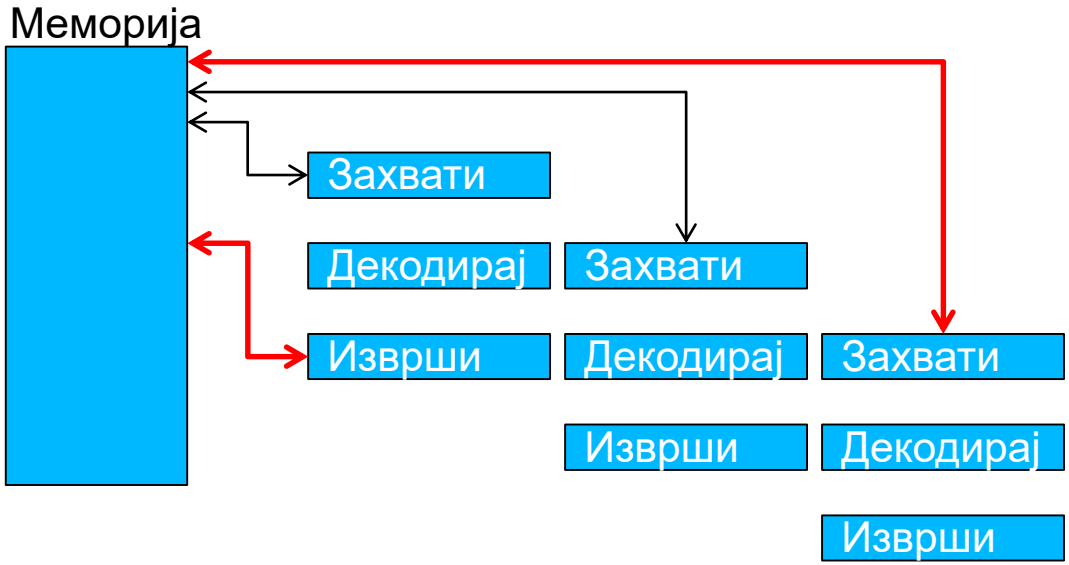
```
_conv:
  a1 = 0
start:
  a1 > 30
  if (T) jmp end:
    x0 = mem[i0]
    i0 = i0 + 1
    y0 = mem[i4]
    i4 = i4 + 1
    a0 = x0 * y0
    mem[i1] = a0
    i1 = i1 + 1
    a1 = a1 + 1
    jmp start
end:
    i7 = mem[i6]
    jmp i7
```

```
_conv:
  a1 = 0
start:
  a1 > 30
  if (T) jmp end:
    x0 = mem[i0]; i0 += 1
    y0 = mem[i4]; i4 += 1
    a0 = x0 * y0
    mem[i1] = a0; i1 += 1
    a1 = a1 + 1
    jmp start
end:
    i7 = mem[i6]
    jmp i7
```

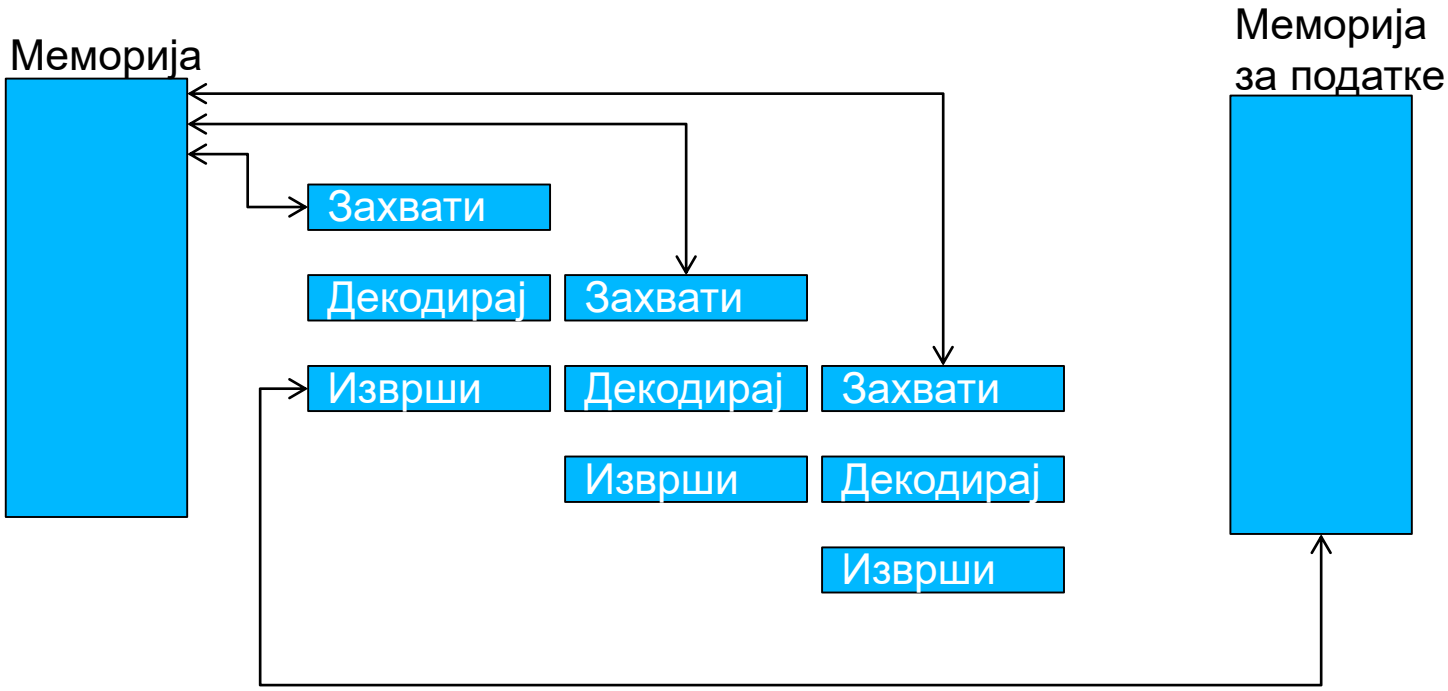
Харвард архитектура



Харвард архитектура



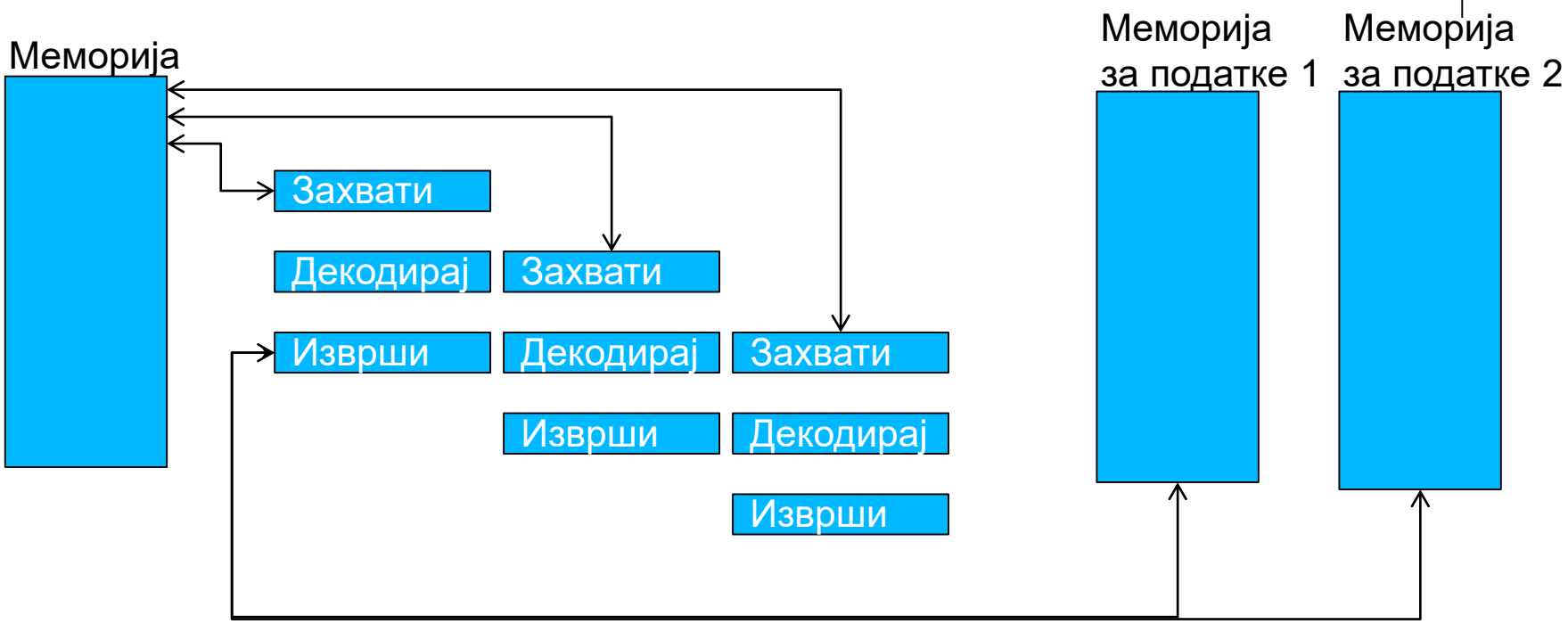
Харвард архитектура



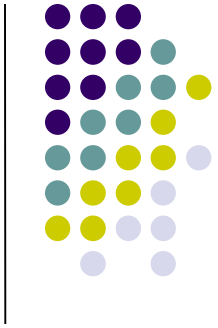

```
c = a * b
```

Колико приступа меморији?

Харвард архитектура



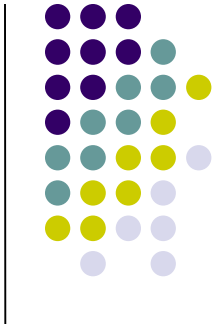

```
__memA int ary1[100];
__memB int ary2[100];
```



```
_Fract aryA[N];
_Fract aryB[N];
_Fract aryC[N];

void conv() {
  int i;
  _Fract* pA = &aryA[0];
  _Fract* pB = &aryB[0];
  _Fract* pC = &aryC[0];
  for (i = 0; i < N; ++i) {
    *pC++ = *pA++ * *pB++;
  }
}
```

```
__memX _Fract aryA[N];
__memY _Fract aryB[N];
__memX _Fract aryC[N];

void conv() {
  int i;
  for (i = 0; i < N; ++i) {
    aryC[i] = aryA[i] * aryB[i];
  }
}
```

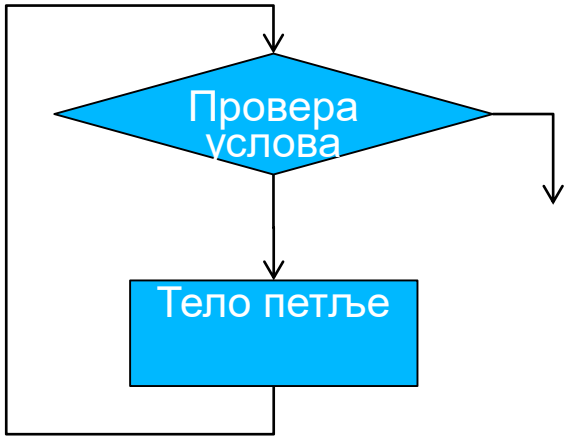
```
__memX _Fract aryA[N];
__memY _Fract aryB[N];
__memX _Fract aryC[N];

void conv() {
  int i;
  __memX _Fract* pA = &aryA[0];
  __memY _Fract* pB = &aryB[0];
  __memX _Fract* pC = &aryC[0];
  for (i = 0; i < N; ++i) {
    *pC++ = *pA++ * *pB++;
  }
}
```

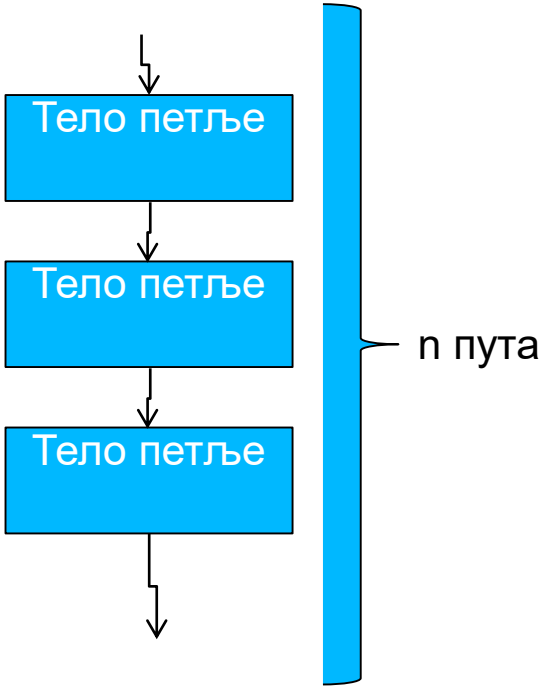


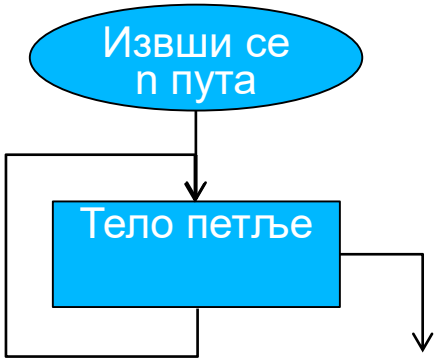
```
_conv:
  a1 = 0
start:
  a1 > 30
  if (T) jmp end:
    x0 = mem[i0]; i0 += 1
    y0 = mem[i4]; i4 += 1
    a0 = x0 * y0
    mem[i1] = a0; i1 += 1
    a1 = a1 + 1
    jmp start
end:
    i7 = mem[i6]
    jmp i7
```

```
_conv:
  a1 = 0
start:
  a1 > 30
  if (T) jmp end:
    x0 = xmem[i0]; i0 += 1; y0 = ymem[i4]; i4 += 1
    a0 = x0 * y0
    xmem[i1] = a0; i1 += 1
    a1 = a1 + 1
    jmp start
end:
    i7 = mem[i6]
    jmp i7
```

Хардверски подржане петље



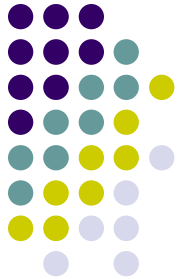




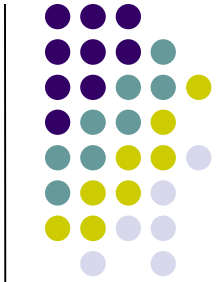
- Петље код којих је број итерација познат већ током превођења
- Петље код којих је број итерација познат пре него што петља почне

NIT

Хардверски подржане петље

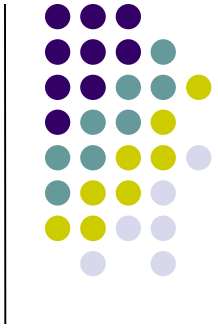


```
for (i = 0; i < NUMBER_OF_ITERATIONS; i++)
for (i = NUMBER_OF_ITERATIONS; i > 0; i--)
for (i = 0; i++ < NUMBER_OF_ITERATIONS; )
for (i = NUMBER_OF_ITERATIONS; i-- > 0; )
for (i = 0; i < NUMBER_OF_ITERATIONS; ++i)
for (i = NUMBER_OF_ITERATIONS;i>0; --i)
for (i = 0; ++i < NUMBER_OF_ITERATIONS + 1; )
for (i = NUMBER_OF_ITERATIONS + 1; --i > 0; )
```



```
__memX _Fract aryA[N];
__memY _Fract aryB[N];
__memX _Fract aryC[N];

void conv() {
  int i;
  for (i = 0; i < N; ++i) {
    aryC[i] = aryA[i] * aryB[i];
  }
}
```

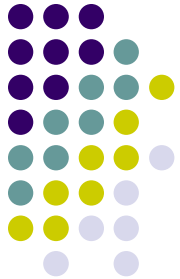
```
__memX _Fract aryA[N];
__memY _Fract aryB[N];
__memX _Fract aryC[N];

void conv() {
  int i;
  __memX _Fract* pA = &aryA[0];
  __memY _Fract* pB = &aryB[0];
  __memX _Fract* pC = &aryC[0];
  for (i = 0; i < N; ++i) {
    *pC++ = *pA++ * *pB++;
  }
}
```



```
_conv:
  a1 = 0
start:
  a1 > 30
  if (T) jmp end:
    x0 = xmem[i0]; i0 += 1; y0 = ymem[i4]; i4 += 1
    a0 = x0 * y0
    xmem[i1] = a0; i1 += 1
    a1 = a1 + 1
    jmp start
end:
    i7 = mem[i6]
    jmp i7
```

```
_conv:
  hw_loop(31), end
    x0 = xmem[i0]; i0 += 1; y0 = ymem[i4]; i4 += 1
    a0 = x0 * y0
    xmem[i1] = a0; i1 += 1
end:
    i7 = mem[i6]
    jmp i7
```

Хардверски стек позива функција

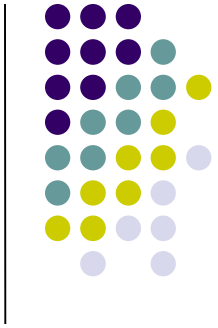


```
push pc
jmp addr
```

```
call addr
```

```
pop reg
jmp reg
```

```
ret
```

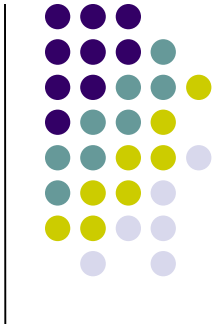


```
_conv:
  hw_loop(31), end
    x0 = xmem[i0]; i0 += 1; y0 = ymem[i4]; i4 += 1
    a0 = x0 * y0
    xmem[i1] = a0; i1 += 1
end:
    i7 = mem[i6]
    jmp i7
```

```
_conv:
  hw_loop(31), end
    x0 = xmem[i0]; i0 += 1; y0 = ymem[i4]; i4 += 1
    a0 = x0 * y0
    xmem[i1] = a0; i1 += 1
end:
    ret
```

```
i6 += 1
xmem[i6] = pc
jmp conv
i6 -= 1
```

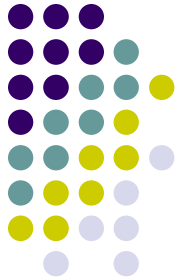
```
call conv
```



```
_conv:
  hw_loop(31), end
    x0 = xmem[i0]; i0 += 1; y0 = ymem[i4]; i4 += 1
    a0 = x0 * y0
    xmem[i1] = a0; i1 += 1
end:
    ret
```

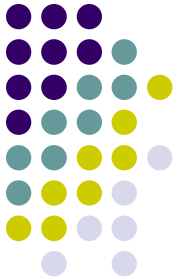
```
_conv:
  x0 = xmem[i0]; i0 += 1; y0 = ymem[i4]; i4 += 1
  hw_loop(31), end
    x0 = xmem[i0]; i0 += 1; y0 = ymem[i4]; i4 += 1; a0 = x0 * y0
    xmem[i1] = a0; i1 += 1
end:
    ret
```

Хардверски подржан кружни бафер



```
__attribute__(align(128))


p = ary;
for (...)
{
    ...*p...
    p = CIRC_INC(p, MOD128, 1);
}
```

Векторске операције GCC



```
int8_t A[200];
int8_t B[200];
int8_t C[200];
for (i = 0; i < 200; ++i)
{
    C[i] = A[i] * B[i];
}

int8_t __attribute__ ((vector_size(8))) A[25];
int8_t __attribute__ ((vector_size(8))) B[25];
int8_t __attribute__ ((vector_size(8))) C[25];
for (i = 0; i < 25; ++i)
{
    C[i] = A[i] * B[i];
}

int8_t __attribute__ ((vector_size(8))) x = {1, 2, 3, 4, 5, 6, 7, 8};
```

Векторске операције GCC – ARM NEON

```
int8_t A[200];
int8_t B[200];
int8_t C[200];
for (i = 0; i < 200; ++i)
{
    C[i] = A[i] + B[i];
}
```

```
int8_t A[200];
int8_t B[200];
int8_t C[200];
for (i = 0; i < 25; i += 8)
{
    _Int8x8 a = vld1_s8(&A[i]); // int8x8_t, може кроз typdef у заглављу
    _Int8x8 b = vld1_s8(&B[i]);
    vst1_s8(&C[i], vadd_s8(a, b)); // мада овде може и a * b
}
```