

PACTOR-2/3/4

**Advanced Data Compression:
Huffman/PMC decoder, RLE**

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PACTOR Advanced Data Compression

P2, P3 and P4 use automatic on-line data compression comprising Huffman and run-length encoding as well as Pseudo-Markov Compression (PMC, see below). The information sending system (ISS) automatically checks, whether one of these compression modes or the original ASCII code leads to the shortest data package, which depends on the probability of occurrence of the characters. Hence, there is no risk of losing throughput capacity. Of course, PACTOR is still capable to transfer any given binary information, e.g. programs or picture and voice files. In case of a binary data transfer, the on-line data compression normally switches off automatically due to the character distribution. An external data compression in the terminal program is usually performed instead.

Huffman compression exploits the “one-dimensional” probability distribution of the characters in plain texts. The more frequently a character occurs, the shorter its Huffman symbol has to be.

Markov compression can be considered as a “double” Huffman compression, since it not only makes use of the simple probability distribution, but of the “two-dimensional” probability. For each preceding character, a probability distribution of the very next character can be calculated. For example, if the actual character is “e”, it is very likely that “i” or “s” occurs next, but extremely unlikely that an “X” follows. The resulting probability distributions are much more concentrated than the simple one-dimensional distribution and thus lead to a considerably better compression. Unfortunately, there are two drawbacks: Since for each ASCII character a separate coding table is required, the entire Markov coding table becomes impractically large. Additionally, the two-dimensional distribution and thus the achievable compression factor depends much more on the kind of text than the simple character distribution. We have therefore chosen a slightly modified approach which we called Pseudo-Markov Compression (PMC), because it can be considered as a hybrid between Markov- and Huffman encoding. In PMC, the Markov encoding is limited to the 16 most frequent “preceding” characters. All other characters trigger normal Huffman compression of the very next character. This reduces the Markov coding table to a reasonable size and also makes the character probabilities less critical, since especially the less frequent characters tend to have unstable probability distributions. Nevertheless, for optimum compression, two different tables for English and German texts are defined in the PACTOR-II and -III protocols and automatically chosen. When transferring plain text, PMC yields a compression factor of around 1.9 compared to 8-bit ASCII.

Run-length encoding (RLE) allows the effective compression of longer sequences of identical bytes. The special prefix byte “0x1D” is defined, which initiates a 3 byte run length code. The second byte is called the “code byte” and contains the original code of the transferred byte within the range of the entire ASCII character set. The third byte provides the number of code bytes to be displayed on the receiving side within the range between “0x01” to “0x60”. Values between “0x00” and “0x1f” are transferred as “0x60” to “0x7f”, values between “0x20” and “0x60” are transferred without any change. For example, the sequence “AAAAAAAA” is transferred using the 3 byte run-length code “0x1D 0x41 0x68”.

Example Source Code Routines

```
#define IDLE 0x1E

/*****
 * printr
 *
 * generic data output routine
 *****/

void printr(unsigned char outbyte)
{
    // put outbyte to display or whatever output device
    // printf("%c",outbyte);
}

/*****
 * ascii_decoder
 *
 * rxpackx: pointer to start of original (encoded) data field
 * rxlen: number of bytes contained in original (encoded) data field
 *****/

void ascii_decoder(unsigned char *rxpackx, unsigned int rxlen)
{
    unsigned int i;

    for(i=0;i<rxlen;i++)
    {
        if (rxpackx[i]!=IDLE)
        {
            printr(rxpackx[i]);
        }
    }
}
```

```

/*****
 * huffman_decoder
 *
 * rxpackx: pointer to start of original (encoded) data field
 * rxlen: number of bytes contained in original (encoded) data field
 *****/

void huffman_decoder(unsigned char *rxpackx,unsigned int rxlen)
{
    unsigned int i,j;
    unsigned short offset;
    unsigned char curbyte,outbyte;

    offset=0;

    for(i=0;i<rxlen;i++)
    {
        curbyte=rxpackx[i];          // next input byte

        for(j=0;j<8;j++)
        {
            if(curbyte&1)
                offset+=2;
            offset=huftab[offset>>1];
            curbyte>>=1;

            if (offset>767)          // data ready?
            {
                outbyte=offset&0xff;
                if(outbyte!=IDLE)
                {
                    printr(outbyte);

                }
                else

                offset=0;          // next output byte

            }

        }

    }

}

```

```

/*****
* pmc_decoder
*
* rxpackx: pointer to start of original (encoded) data field
* rxlen: number of bytes contained in original (encoded) data field
* english: 0=German data, 1=English data
*****/

void pmc_decoder(unsigned char *rxpackx,unsigned int rxlen,
                 unsigned char english)
{
    unsigned int i,j;
    unsigned short table_offset=0,offset=0;
    unsigned char curbyte,outbyte;

    for(i=0;i<rxlen;i++)
    {
        curbyte=rxpackx[i];          // next input byte

        for(j=0;j<8;j++)
        {
            if(curbyte&1)
                offset+=2;
            offset=huftab[(table_offset+offset)>>1];
            curbyte>>=1;

            if (offset>767)          // data ready?
            {
                outbyte=offset&0xff;

                table_offset=reftab[outbyte];
                if (table_offset)
                {
                    if(english)
                        table_offset+=8128;
                }

                if(outbyte!=IDLE)
                {
                    printr(outbyte);
                }

                offset=0;          // next output byte
            }
        }
    }
}

```

```
//=====
```

```
// Huffman/PMC-Decoding tables
```

```
unsigned short huftab[]=
```

```
{  
  4,8,12,16,800,20,24,28,32,869,36,40,  
  44,48,52,56,60,878,64,873,882,68,884,72,  
  76,80,883,84,88,868,865,92,96,100,104,885,  
  876,108,872,112,116,871,120,877,781,778,879,867,  
  124,128,132,136,140,144,866,870,148,152,887,836,  
  156,875,160,164,890,168,814,812,172,176,180,184,  
  188,851,192,196,200,204,208,833,837,212,880,886,  
  216,816,838,220,224,834,228,835,841,232,852,236,  
  847,240,244,248,848,252,256,260,817,264,850,268,  
  272,276,280,808,809,844,846,284,858,288,845,292,  
  825,296,855,821,889,300,818,819,820,822,823,824,  
  840,304,842,853,854,796,888,308,843,831,829,312,  
  316,320,881,849,874,839,324,813,328,826,332,336,  
  340,344,348,801,815,352,356,360,810,364,802,805,  
  807,368,863,372,376,380,384,806,811,830,832,804,  
  828,856,388,803,392,396,400,404,408,412,416,420,  
  424,428,432,857,436,440,444,448,827,860,452,456,  
  460,464,468,472,476,480,484,488,492,496,500,504,  
  859,861,895,894,893,892,891,864,862,799,797,795,  
  793,792,791,790,789,788,787,786,785,784,798,783,  
  782,780,779,777,776,775,774,773,772,771,770,769,  
  768,794,
```

```
// german rx-markov-table follows
```

```
  4,8,12,800,16,20,24,28,32,36,868,40,  
  44,48,52,56,60,869,64,68,72,76,80,84,  
  88,865,92,883,96,100,104,108,887,885,112,116,  
  866,890,873,120,836,848,124,851,128,886,833,132,  
  877,136,834,140,845,871,144,148,152,837,878,870,  
  156,854,160,875,850,164,168,838,172,176,852,180,  
  843,184,188,192,844,872,196,200,204,839,840,808,  
  208,876,212,835,879,817,216,781,220,224,841,855,  
  874,784,228,232,882,236,853,880,240,244,818,867,  
  822,248,252,813,858,256,811,820,821,824,847,856,  
  859,260,264,884,268,790,819,846,272,825,276,280,  
  284,288,881,292,823,842,296,300,304,308,312,316,  
  320,324,807,816,888,328,332,336,340,344,348,352,  
  356,360,364,368,372,376,380,384,388,392,396,400,  
  404,408,412,416,420,424,428,432,436,440,444,448,  
  452,456,460,464,468,472,476,480,484,488,492,496,  
  500,504,768,769,770,771,772,773,774,775,776,777,  
  778,779,780,782,783,785,786,787,788,789,791,792,  
  793,794,795,796,797,798,799,801,802,803,804,805,  
  806,809,810,812,814,815,826,827,828,829,830,831,  
  832,849,857,860,861,862,863,864,889,891,892,893,  
  894,895,  
  4,8,12,16,882,878,20,873,24,800,28,32,  
  36,883,40,44,876,48,884,52,56,877,60,64,  
  68,72,76,872,866,80,84,871,870,781,868,88,  
  867,885,92,875,96,100,104,812,108,813,888,112,  
  881,890,116,814,887,791,120,880,124,869,865,886,  
  128,132,136,140,144,148,152,156,160,164,809,879,  
  168,172,176,180,184,188,192,196,200,204,208,212,  
  216,220,224,228,232,236,240,244,248,252,256,260,  
  264,268,272,276,280,284,288,292,296,300,304,308,  
  312,316,320,324,328,332,336,340,344,348,352,356,
```

360,364,368,372,376,380,384,388,392,396,400,404,
408,412,416,420,424,428,432,436,440,444,448,452,
456,460,464,468,472,476,480,484,488,492,496,500,
504,768,769,770,771,772,773,774,775,776,777,778,
779,780,782,783,784,785,786,787,788,789,790,792,
793,794,795,796,797,798,799,801,802,803,804,805,
806,807,808,810,811,815,816,817,818,819,820,821,
822,823,824,825,826,827,828,829,830,831,832,833,
834,835,836,837,838,839,840,841,842,843,844,845,
846,847,848,849,850,851,852,853,854,855,856,857,
858,859,860,861,862,863,864,874,889,891,892,893,
894,895,
4,8,12,800,16,20,24,871,28,868,32,869,
36,40,44,884,48,52,878,56,883,60,865,814,
64,885,812,873,68,890,72,781,76,80,84,875,
88,872,879,92,870,96,876,100,813,104,108,112,
866,886,116,783,120,124,887,128,784,880,877,132,
136,140,809,826,882,144,148,152,156,160,164,168,
807,867,172,176,180,184,188,192,196,200,204,208,
212,216,220,224,228,232,236,240,244,248,252,256,
260,264,268,272,276,280,284,288,292,296,300,304,
308,312,316,320,324,328,332,336,340,344,348,352,
356,360,364,368,372,376,380,384,388,392,396,400,
404,408,412,416,420,424,428,432,436,440,444,448,
452,456,460,464,468,472,476,480,484,488,492,496,
500,504,768,769,770,771,772,773,774,775,776,777,
778,779,780,782,785,786,787,788,789,790,791,792,
793,794,795,796,797,798,799,801,802,803,804,805,
806,808,810,811,815,816,817,818,819,820,821,822,
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848,849,850,851,852,853,854,855,856,857,858,859,
860,861,862,863,864,874,881,888,889,891,892,893,
894,895,
4,8,12,16,869,878,20,24,884,28,32,871,
36,867,883,40,44,879,876,48,877,52,882,56,
886,60,800,64,875,68,72,880,76,865,80,866,
868,84,88,92,872,96,100,781,104,813,890,108,
870,112,116,120,124,791,885,128,132,136,140,144,
148,152,815,873,888,156,160,164,168,172,176,180,
184,188,192,196,200,204,208,212,216,220,224,228,
232,236,240,244,248,252,256,260,264,268,272,276,
280,284,288,292,296,300,304,308,312,316,320,324,
328,332,336,340,344,348,352,356,360,364,368,372,
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784,785,786,787,788,789,790,792,793,794,795,796,
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824,825,826,827,828,829,830,831,832,833,834,835,
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132,809,136,140,144,148,152,156,160,164,168,172,
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416, 420, 424, 428, 432, 436, 440, 444, 448, 452, 456, 460,
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782, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795,
796, 797, 798, 799, 801, 802, 803, 804, 805, 806, 807, 808,
810, 811, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824,
825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836,
837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848,
849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860,
861, 862, 863, 864, 874, 881, 886, 888, 889, 891, 892, 893,
894, 895,
4, 8, 12, 869, 16, 800, 20, 24, 28, 873, 32, 36,
882, 40, 44, 865, 48, 52, 56, 890, 885, 814, 60, 64,
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876, 88, 92, 96, 870, 100, 104, 108, 880, 112, 784, 872,
116, 120, 783, 124, 866, 867, 871, 128, 809, 878, 132, 875,
877, 886, 889, 136, 140, 144, 826, 148, 152, 156, 160, 164,
168, 807, 172, 176, 180, 184, 188, 192, 196, 200, 204, 208,
212, 216, 220, 224, 228, 232, 236, 240, 244, 248, 252, 256,
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452, 456, 460, 464, 468, 472, 476, 480, 484, 488, 492, 496,
500, 504, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777,
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836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847,
848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859,
860, 861, 862, 863, 864, 868, 874, 881, 888, 891, 892, 893,
894, 895,
4, 8, 12, 16, 20, 884, 800, 24, 28, 869, 32, 36,
867, 873, 883, 879, 40, 44, 880, 48, 52, 56, 865, 60,
64, 68, 72, 76, 781, 813, 80, 871, 885, 84, 88, 886,
887, 92, 870, 812, 96, 866, 100, 814, 104, 875, 108, 889,
882, 890, 112, 876, 116, 120, 868, 877, 124, 872, 878, 128,
132, 136, 140, 807, 826, 144, 148, 152, 156, 160, 164, 168,
172, 176, 180, 184, 188, 192, 196, 200, 204, 208, 212, 216,
220, 224, 228, 232, 236, 240, 244, 248, 252, 256, 260, 264,
268, 272, 276, 280, 284, 288, 292, 296, 300, 304, 308, 312,
316, 320, 324, 328, 332, 336, 340, 344, 348, 352, 356, 360,
364, 368, 372, 376, 380, 384, 388, 392, 396, 400, 404, 408,
412, 416, 420, 424, 428, 432, 436, 440, 444, 448, 452, 456,
460, 464, 468, 472, 476, 480, 484, 488, 492, 496, 500, 504,
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793, 794, 795, 796, 797, 798, 799, 801, 802, 803, 804, 805,
806, 808, 809, 810, 811, 815, 816, 817, 818, 819, 820, 821,
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847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858,
859, 860, 861, 862, 863, 864, 874, 881, 888, 891, 892, 893,
894, 895,
4, 869, 8, 12, 873, 800, 16, 20, 24, 865, 28, 885,
32, 876, 36, 40, 882, 44, 48, 781, 52, 879, 56, 60,
887, 64, 812, 813, 68, 814, 866, 72, 76, 80, 878, 883,
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204,208,212,216,220,224,228,232,236,240,244,248,
252,256,260,264,268,272,276,280,284,288,292,296,
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396,400,404,408,412,416,420,424,428,432,436,440,
444,448,452,456,460,464,468,472,476,480,484,488,
492,496,500,504,768,769,770,771,772,773,774,775,
776,777,778,779,780,782,783,785,786,787,788,789,
790,791,792,793,794,795,796,797,798,799,801,802,
803,804,805,806,807,808,809,810,811,815,816,817,
818,819,820,821,822,823,824,825,826,827,828,829,
830,831,832,833,834,835,836,837,838,839,840,841,
842,843,844,845,846,847,848,849,850,851,852,853,
854,855,856,857,858,859,860,861,862,863,864,867,
868,870,871,874,877,880,881,884,888,891,892,893,
894,895,
4,8,12,16,20,878,24,885,876,28,884,32,
882,36,40,44,883,48,867,52,877,56,866,60,
64,800,872,868,68,72,875,871,791,76,80,84,
88,889,888,92,873,890,96,781,870,880,814,100,
104,108,813,112,116,120,124,815,886,128,132,136,
140,144,148,152,156,160,164,168,172,176,180,184,
188,192,196,200,204,208,212,216,220,224,228,232,
236,240,244,248,252,256,260,264,268,272,276,280,
284,288,292,296,300,304,308,312,316,320,324,328,
332,336,340,344,348,352,356,360,364,368,372,376,
380,384,388,392,396,400,404,408,412,416,420,424,
428,432,436,440,444,448,452,456,460,464,468,472,
476,480,484,488,492,496,500,504,768,769,770,771,
772,773,774,775,776,777,778,779,780,782,783,784,
785,786,787,788,789,790,792,793,794,795,796,797,
798,799,801,802,803,804,805,806,807,808,809,810,
811,812,816,817,818,819,820,821,822,823,824,825,
826,827,828,829,830,831,832,833,834,835,836,837,
838,839,840,841,842,843,844,845,846,847,848,849,
850,851,852,853,854,855,856,857,858,859,860,861,
862,863,864,865,869,874,879,881,887,891,892,893,
894,895,
4,878,8,12,16,20,24,883,28,882,870,32,
36,40,800,44,877,48,867,884,869,52,56,876,
791,871,60,813,64,68,880,72,868,76,80,84,
865,875,88,866,872,873,92,96,885,100,104,108,
112,812,890,116,120,124,128,132,136,140,144,148,
152,156,160,164,168,172,176,180,184,188,192,196,
200,204,208,212,216,220,224,228,232,236,240,244,
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