Xilinx Zynq FPGA,TI DSP, MCU 기반의 프로그래밍 전문가 과정

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<Red_Black_Tree>

삽입과 출겨(입출력) 속도가 빠르고 검색 속도는 빠르다.
하지만 데이터의 양들이 많아져 느려질 수 있는데…

* 많이 지워지고 생성되는 것이 많을 때는 적합하긴 하다.
* 전체적으로 평균치 이상의 성능을 가지기 때문에 여기저기서 많이 쓴다.

data		color
Left	Parent	right

* 이런식으로 heap 영역에 데이터가 쌓인다. 구조체에 선언되는 파트가 많아져서 그렇다.
* 만들면서 더미 공간이 2 개가 생긴다. (로테이션 , 색의 변경 등 여러 규칙에 비교해 변화를 주기위해 쓰는 부분이다.)

<규칙>

1. 루트 노드는 항상 검정
2. 잎사귀 노드 어디를 가던지 거치는 검정색의 개수가 서로 모두 같다.
3. 빨강이 연속해서 두개오면 회전하거나 색상을 바꾼다.
4. 현재 기준점에서 부모노드와 삼촌의 색상이 같으면 색상만 병경함.
(할아버지가 빨간색이 되고 자식들은 검정색이 된다.)
5. 3 번 규칙을 만족하는데 4 번이 만족되지 않으면 회전.
6. 제일 긴 노드와 제일 짧은 노드의 차가 2 배 까지는 허용된다.

<Red_Black Tree _code >

```
#include <time.h>
#include <stdio.h>
#include <stdlib.h>
#include <stdbool.h>

#defineBLACK  0
#defineRED              1

typedef struct __rb_node
{
        int data;
        int color;

        struct __rb_node *left;
        struct __rb_node *right;
        struct __rb_node *parent;
} rb_node;

typedef struct __rb_tree
```

```
{
	struct __rb_node *root;
	struct __rb_node *nil;
} rb_tree;

bool is_dup(int *arr, int cur_idx)
{
	int i, tmp = arr[cur_idx];

	for(i = 0; i < cur_idx; i++)
		if(tmp == arr[i])
			return true;

	return false;
}

void init_rand_arr(int *arr, int size)
{
	int i;

	for(i = 0; i < size; i++)
	{
redo:
		//arr[i] = rand() % 15 + 1;
		arr[i] = rand() % 200 + 1;

		if(is_dup(arr, i))
		{
			printf("%d dup! redo rand()\n", arr[i]);
			goto redo;
		}
	}
}

void rb_left_rotate(rb_tree **tree, rb_node *x)
{
	rb_node *y;
	rb_node *nil = (*tree)->nil;

	y = x->right;
	x->right = y->left;

	if(y->left != nil)
		y->left->parent = x;

	y->parent = x->parent;

	if(x == x->parent->left)
		x->parent->left = y;
```

```
	else
		x->parent->right = y;

	y->left = x;
	x->parent = y;
}

void rb_right_rotate(rb_tree **tree, rb_node *y)
{
	rb_node *x;
	rb_node *nil = (*tree)->nil;

	x = y->left;
	y->left = x->right;

	if(nil != x->right)
		x->right->parent = y;

	x->parent = y->parent;

	if(y->parent->left == y)
		y->parent->left = x;
	else
		y->parent->right = x;

	x->right = y;
	y->parent = x;
}

void rb_tree_ins_helper(rb_tree **tree, rb_node *z)
{
	rb_node *x;
	rb_node *y;
	rb_node *nil = (*tree)->nil;

	z->left = z->right = nil;
	y = (*tree)->root;
	x = (*tree)->root->left;
	// 왼쪽에 넣을지 오른쪽에 넣을지 결정시켜주는 코드
	while(x != nil)
	{
		y = x;

		if(x->data > z->data)
			x = x->left;
		else
			x = x->right;
	}
```

```
	z->parent = y;

	if(((*tree)->root == y) || (y->data > z->data))
		y->left = z;
	else
		y->right = z;
}

rb_node *rb_tree_ins(rb_tree **tree, int data)
{
	rb_node *x;
	rb_node *y;
	rb_node *tmp;

	x = (rb_node *)malloc(sizeof(rb_node));
	x->data = data;

	rb_tree_ins_helper(tree, x);

	tmp = x;
	x->color = RED;

	while(x->parent->color)
	{
		if(x->parent == x->parent->parent->left)
		{
			y = x->parent->parent->right;

			if(y->color)
			{
				x->parent->color = BLACK;
				y->color = BLACK;
				x->parent->parent->color = RED;
				x = x->parent->parent;
			}
			else
			{
				if(x->parent->right == x)
				{
					x = x->parent;
					rb_left_rotate(tree, x);
				}

				x->parent->color = BLACK;
				x->parent->parent->color = RED;

				rb_right_rotate(tree, x->parent->parent);
			}
		}
```

```
                else
                {
                        y = x->parent->parent->left;

                        if(y->color)
                        {
                                x->parent->color = BLACK;
                                y->color = BLACK;
                                x->parent->parent->color = RED;
                                x = x->parent->parent;
                        }
                        else
                        {
                                if(x->parent->left == x)
                                {
                                        x = x->parent;
                                        rb_right_rotate(tree, x);
                                }

                                x->parent->color = BLACK;
                                x->parent->parent->color = RED;

                                rb_left_rotate(tree, x->parent->parent);
                        }
                }
        }

        (*tree)->root->left->color = BLACK;

        return tmp;
}

rb_tree *rb_tree_create(void)
{
        rb_tree *rbt;
        rb_node *tmp;

        rbt = (rb_tree *)malloc(sizeof(rb_tree));

        tmp = rbt->nil = (rb_node *)malloc(sizeof(rb_node));
        tmp->parent = tmp->left = tmp->right = tmp;
        tmp->color = BLACK;
        tmp->data = 0;

        tmp = rbt->root = (rb_node *)malloc(sizeof(rb_node));
        tmp->parent = tmp->left = tmp->right = rbt->nil;
        tmp->color = BLACK;
        tmp->data = 0;
```

```
	return rbt;
}

void rb_tree_preorder_print(rb_tree *tree, rb_node *x)
{
	rb_node *nil = tree->nil;
	rb_node *root = tree->root;

	if(x != tree->nil)
	{
		printf("data = %4i, ", x->data);

		if(x->left == nil)
			printf("left = NULL, ");
		else
			printf("left = %4i, ", x->left->data);

		if(x->right == nil)
			printf("right = NULL, ");
		else
			printf("right = %4i, ", x->right->data);

		printf("color = %4i\n", x->color);

		rb_tree_preorder_print(tree, x->left);
		rb_tree_preorder_print(tree, x->right);
	}
}

void rb_tree_print(rb_tree *tree)
{
	rb_tree_preorder_print(tree, tree->root->left);
}

int data_test(int n1, int n2)
{
	if(n1 > n2)
		return 1;
	else if(n1 < n2)
		return -1;
	else
		return 0;
}

rb_node *rb_tree_find(rb_tree *tree, int data)
{
	int tmp;

	rb_node *x = tree->root->left;
```

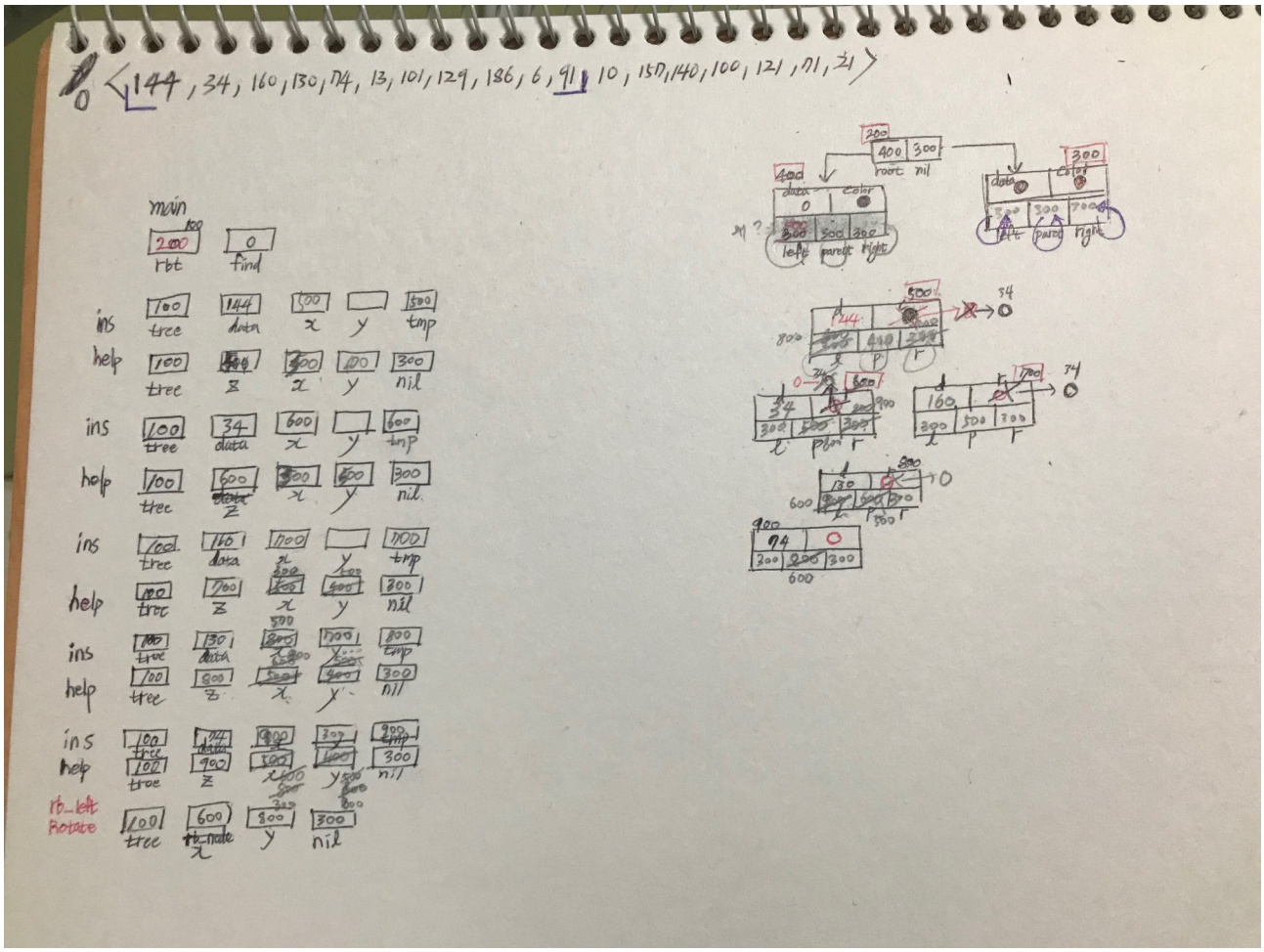
```
	rb_node *nil = tree->nil;

	if(x == nil)
		return 0;

	tmp = data_test(x->data, data);

	while(tmp != 0)
	{
		if(x->data > data)
			x = x->left;
		else
			x = x->right;

		if(x == nil)
			return 0;

		tmp = data_test(x->data, data);
	}

	return x;
}

rb_node *rb_tree_successor(rb_tree *tree, rb_node *x)
{
	rb_node *y;
	rb_node *nil = tree->nil;
	rb_node *root = tree->root;

	if(nil != (y = x->right))
	{
		while(y->left != nil)
			y = y->left;

		return y;
	}
	else
	{
		y = x->parent;

		while(y->right == x)
		{
			x = y;
			y = y->parent;
		}

		if(y == root)
			return nil;
```

```
                return y;
        }
}

void rb_tree_del_fixup(rb_tree *tree, rb_node *x)
{
        rb_node *root = tree->root->left;
        rb_node *w;

        while((!x->color) && (root != x))
        {
                if(x->parent->left == x)
                {
                        w = x->parent->right;

                        if(w->color)
                        {
                                w->color = BLACK;
                                x->parent->color = RED;
                                rb_left_rotate(&tree, x->parent);
                                w = x->parent->right;
                        }

                        if((!w->right->color) && (!w->left->color))
                        {
                                w->color = RED;
                                x = x->parent;
                        }
                        else
                        {
                                if(!w->right->color)
                                {
                                        w->left->color = BLACK;
                                        w->color = RED;
                                        rb_right_rotate(&tree, w);
                                        w = x->parent->right;
                                }

                                w->color = x->parent->color;
                                x->parent->color = BLACK;
                                w->right->color = BLACK;
                                rb_right_rotate(&tree, x->parent);
                                x = root;
                        }
                }
                else
                {
                        w = x->parent->left;
```

```
                        if(w->color)
                        {
                                w->color = BLACK;
                                x->parent->color = 1;
                                rb_right_rotate(&tree, x->parent);
                                w = x->parent->left;
                        }

                        if((!w->right->color) && (!w->left->color))
                        {
                                w->color = RED;
                                x = x->parent;
                        }
                        else
                        {
                                if((!w->right->color) && (!w->left->color))
                                {
                                        w->right->color = BLACK;
                                        w->color = RED;
                                        rb_left_rotate(&tree, w);
                                        w = x->parent->left;
                                }

                                w->color = x->parent->color;
                                x->parent->color = BLACK;
                                w->left->color = BLACK;
                                rb_right_rotate(&tree, x->parent);
                                x = root;
                        }
                }
        }

        x->color = BLACK;
}

void rb_tree_del(rb_tree *tree, rb_node *z)
{
        rb_node *y;
        rb_node *x;
        rb_node *nil = tree->nil;
        rb_node *root = tree->root;

        y = ((z->left == nil) || (z->right == nil)) ?
                        z : rb_tree_successor(tree, z);
        x = (y->left == nil) ? y->right : y->left;

        if(root == (x->parent = y->parent))
                root->left = x;
        else
```

```
	{
		if(y == y->parent->left)
			y->parent->left = x;
		else
			y->parent->right = x;
	}

	if(y != z)
	{
		if(!(y->color))
			rb_tree_del_fixup(tree, x);

		y->left = z->left;
		y->right = z->right;
		y->parent = z->parent;
		y->color = z->color;
		z->left->parent = z->right->parent = y;

		if(z->parent->left == z)
			z->parent->left = y;
		else
			z->parent->right = y;

		free(z);
	}
	else
	{
		if(!(y->color))
			rb_tree_del_fixup(tree, x);

		free(y);
	}
}

int main(void)
{
	int i, size;
	int data[21] = {0};

	rb_tree *rbt = NULL;
	rb_node *find = NULL;

	srand(time(NULL));

	size = sizeof(data) / sizeof(int) - 1;

	init_rand_arr(data, size);

	rbt = rb_tree_create();
```

```
	for(i = 0; i < size; i++)
		rb_tree_ins(&rbt, data[i]);

	rb_tree_print(rbt);

	find = rb_tree_find(rbt, data[5]);

	rb_tree_del(rbt, find);
	printf("\nAfter Delete\n");

	rb_tree_print(rbt);

	return 0;
}
```



74 부터 꼬이기 시작...