External nodes

Without external nodes:

With external nodes:

Example red-black tree

F

E

C

G

J

B

A

D

K

H

external node

(always black)

x

x

red node

black node

KEY

Case 2a possibililties

K

P

S

G

1

2

3

K

G

S

P

1

2

3

K

P

S

G

1

2

3

Before restructuring

After restructuring

G

P

S

K

1

2

3

K

P

S

G

1

2

3

Before restructuring

After restructuring

K

G

S

P

1

2

3

K

P

S

G

1

2

3

G

P

S

K

1

2

3

Recoloring

S

K

P

G

1

2

3

S

Before recoloring

K

G

P

1

2

3

After recoloring