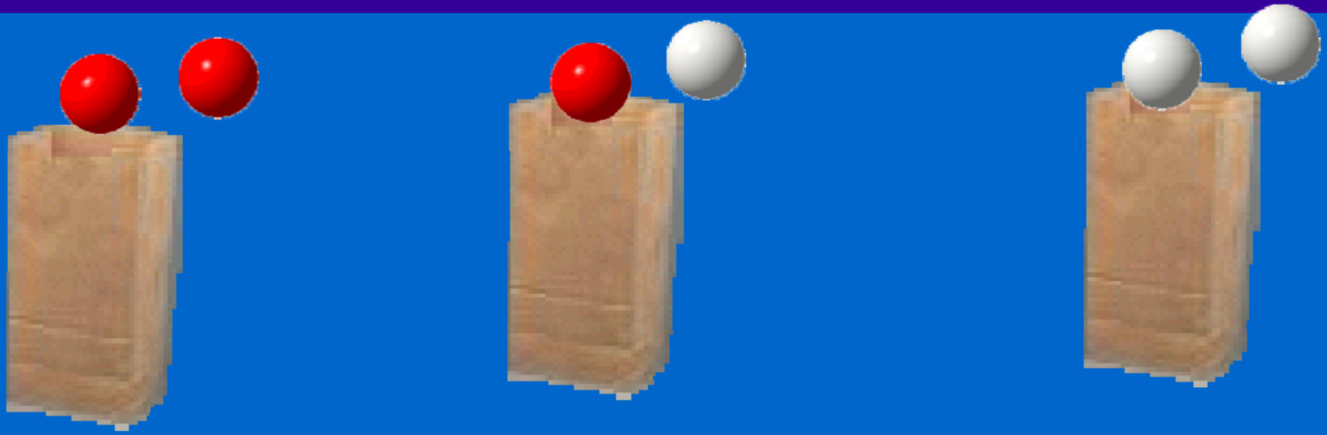
A C++ Program Example: Three Bags

C++ Object Oriented Programming

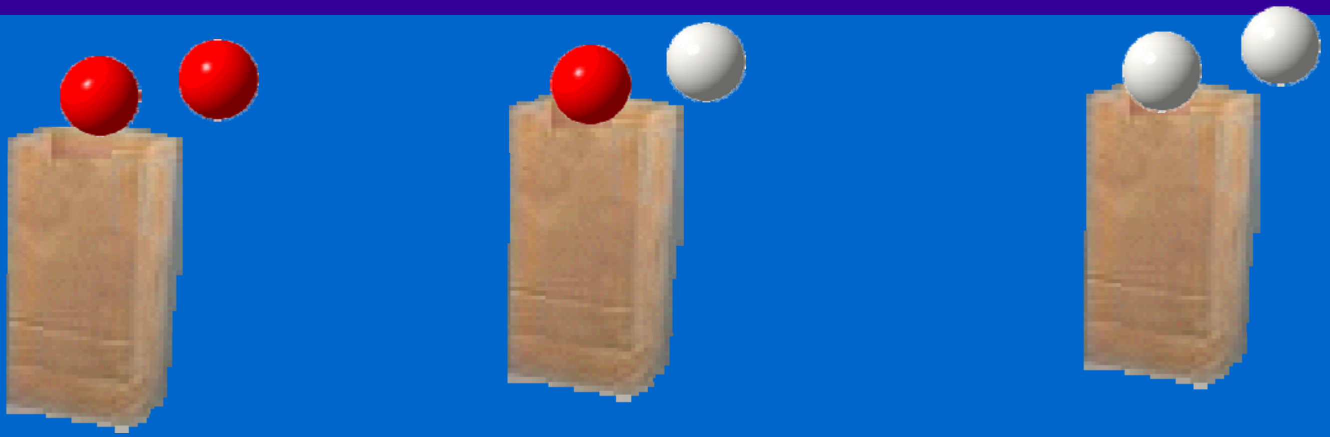
Pei-yih Ting

NTOU CSE

A Simple Probabilistic Experiment



A Simple Probabilistic Experiment



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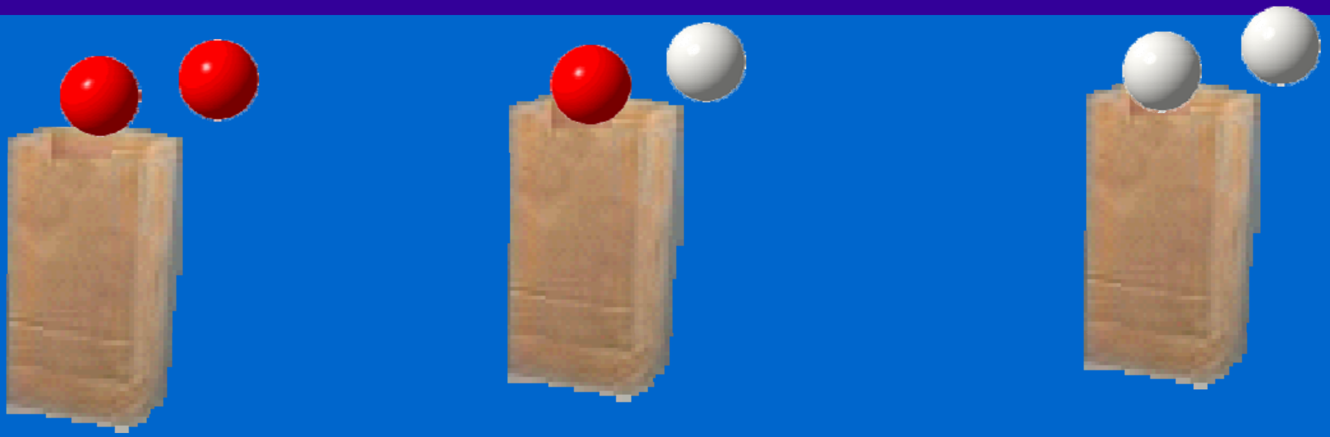
A Simple Probabilistic Experiment



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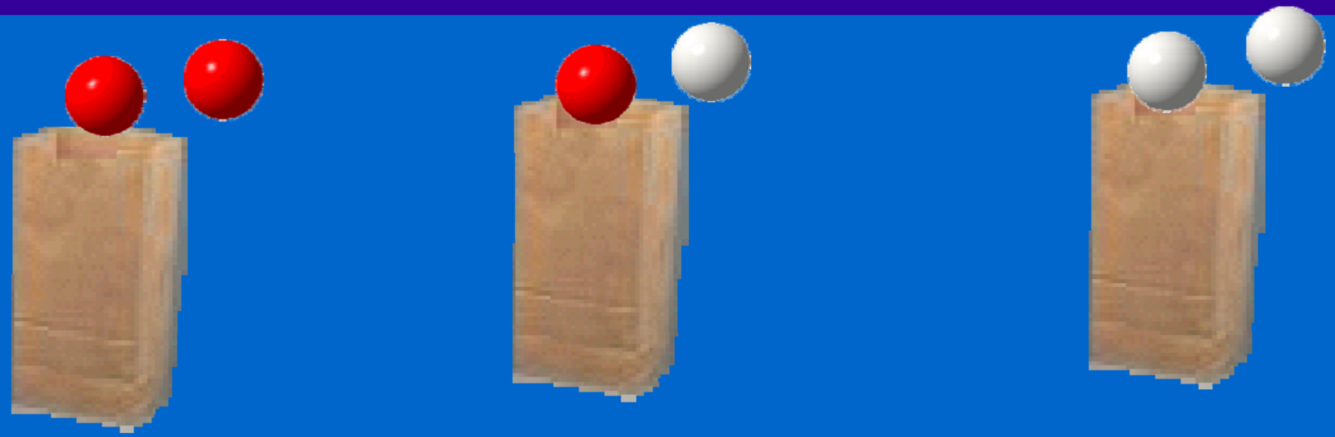

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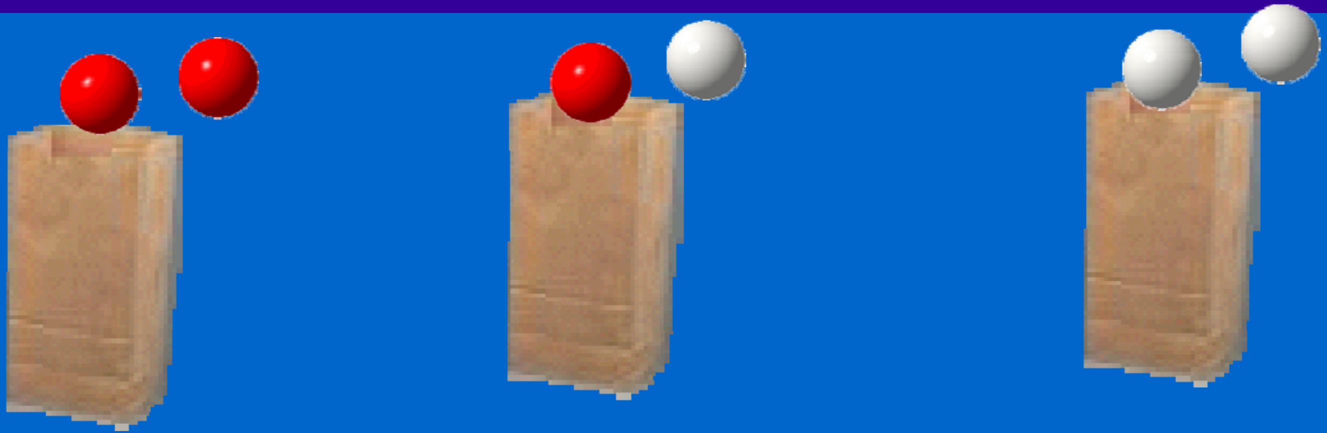

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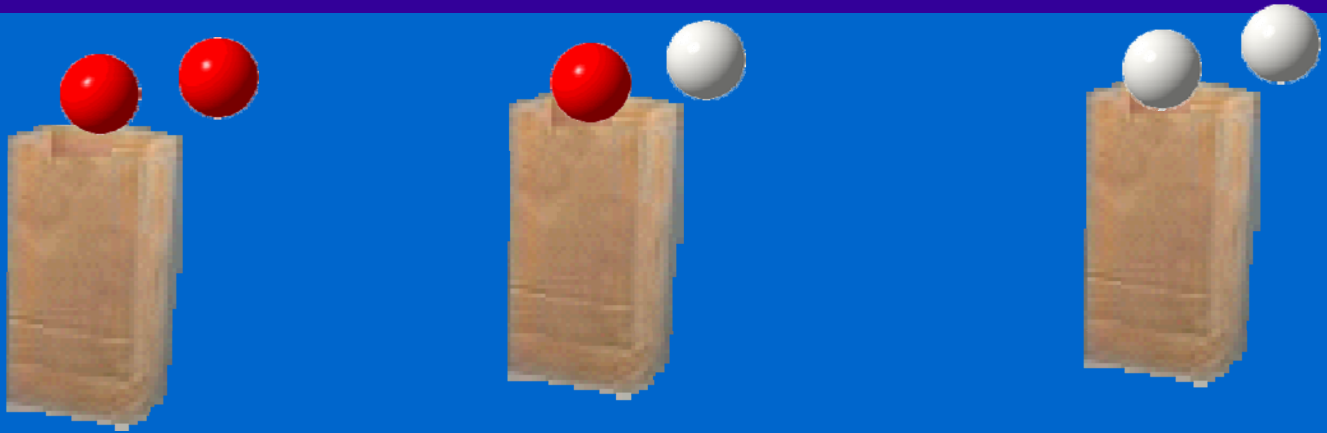

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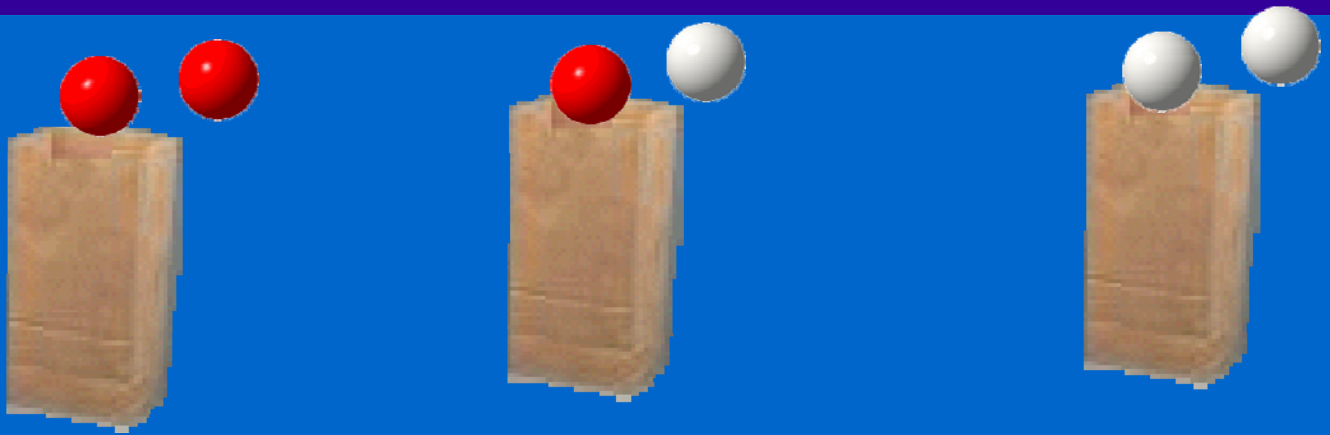

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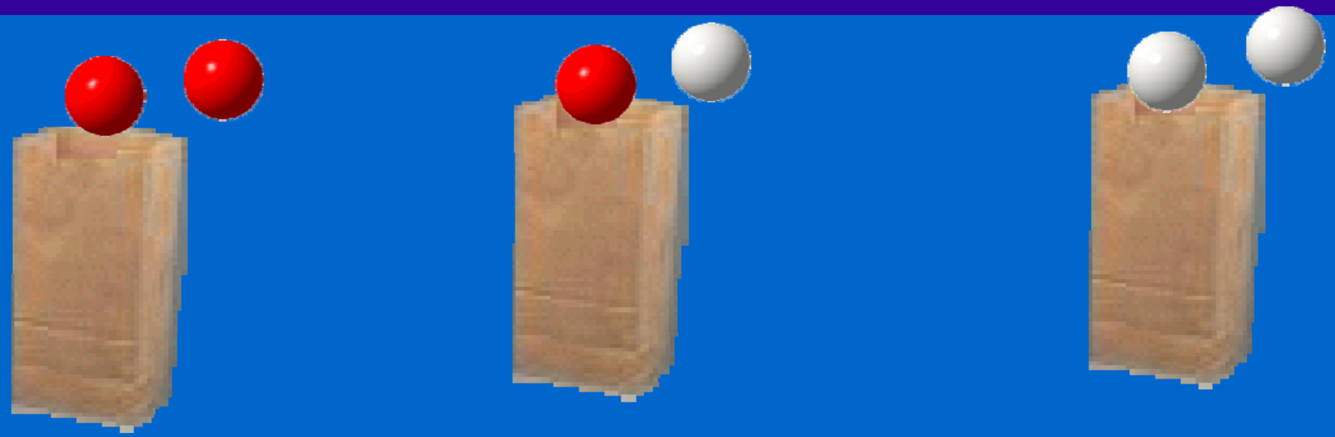

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we want to find out the probability that the **second ball is red** at step 4

蒙提霍爾 (Monty Hall) 問題

「三門問題」最初是美國電視節目 Let’s Make a Deal 中主持人 **Monty Hall** 在節目上玩的一個益智遊戲

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現在製作單位大放送,
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✧ 大部分同學不喜歡機率課程, 尤其是不知道為什麼一定要積分積分的作法, 可是機率問題最有趣的就在於腦筋轉一轉有很多直觀的看法, 很多問題也都直接出現在你的日常生活之中

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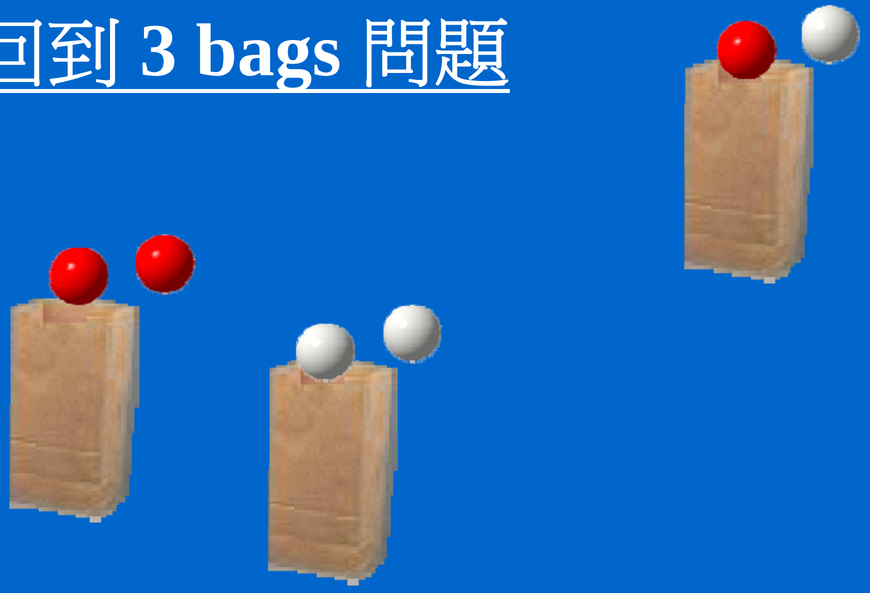
回到 3 bags 問題



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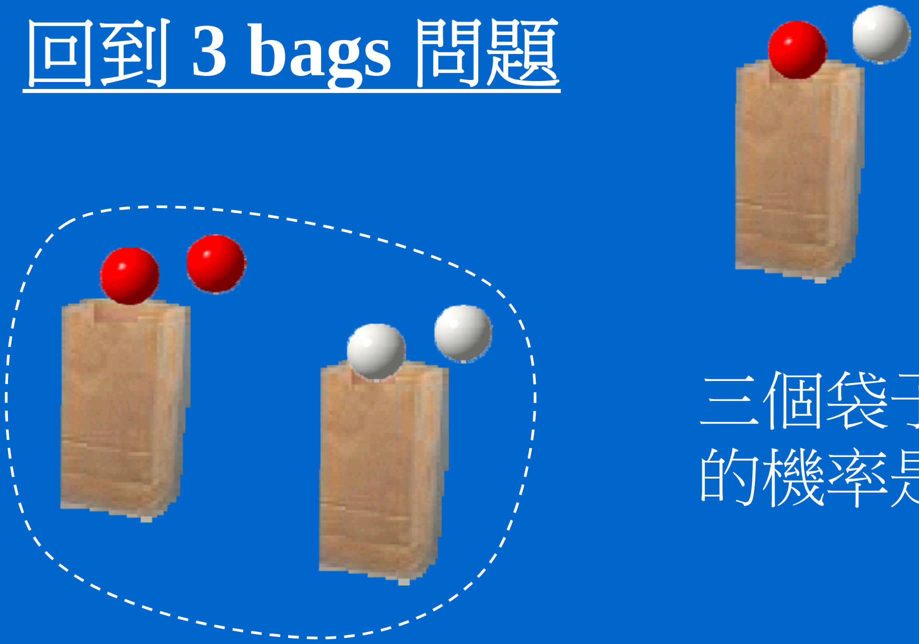

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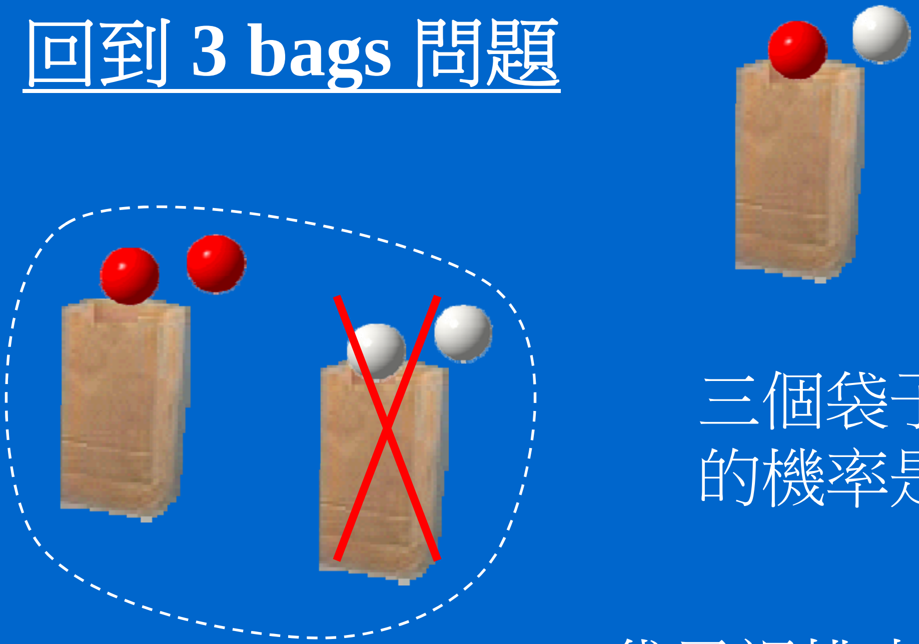

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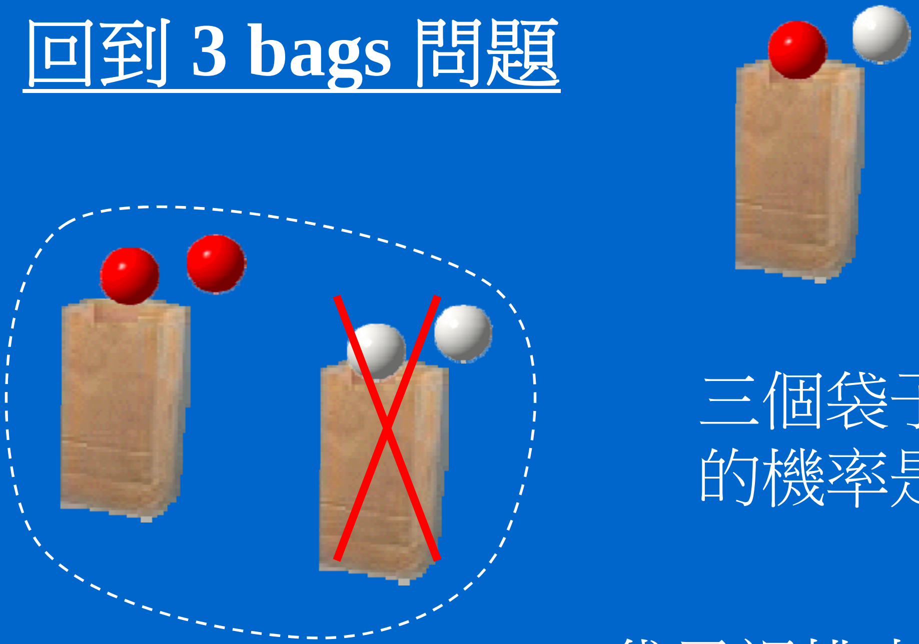

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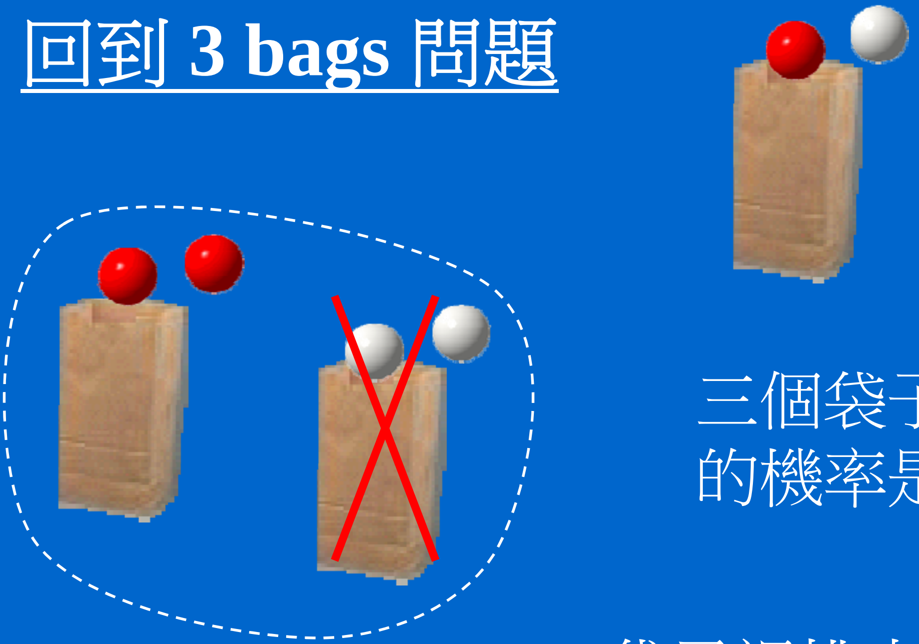

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所以 **2/3** 也就是袋子裡剩下那一個球是紅球的機率

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$$= \frac{1/3}{1/3 + 1/3 \times 1/2} = 2/3$$

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A Program Written in C (2/3)

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

void main()
{
    long i;
    int draw1, draw2, choice, tmp;
    long totalCount=0L,
            redCount=0L;

    srand(time(NULL));
    for (i=0; i<100000L; i++)
    {
        draw1 = rand() % 3; // pick a bag out of the three

        if (draw1 == 0) // (Red, Red)
        {
            totalCount++;
            redCount++;
        }
        else if (draw1 == 1) // (Red, White)
        {
            draw2 = rand() % 2;
            if (draw2 == 0) // the first is Red
                totalCount++;
            else // the first is White
                /* do nothing */;
        }
    }

    printf("Pr(2nd is red | 1st is red)=%lf\n",
      (double)redCount / (double)totalCount);
}
```

Output:

```
Pr(2nd is red | 1st is red)=0.665299
```

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- If you just read the C program alone, can you reconstruct the problem easily and exactly? Not quite easy
- There are many missing pieces of the original problem specification in the above C program.
  - 100000 experiments mixed together (without my explanations, some might have a wrong picture of what the program actually does) Variables totalCount and redCount are something not in the original problem specification.

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    No code is associated with the case that the bag with two white balls is selected.

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$$\begin{tikzcd} \boxed{\text{OOA}} \arrow[r] & \boxed{\text{OOD}} \end{tikzcd}$$

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  Move on to customized OO programming.

$$\boxed{\text{OOA}} \longrightarrow \boxed{\text{OOD}} \longrightarrow \boxed{\text{OOP}}$$

Game Class

```
---------------- 2:Game.h ----------------


#ifndef game_h
#define game_h

#include "Bag.h"

class Game
{
public:
    Bag *getABag();
    Game();
    ~Game();
private:
    Bag *m_bags[3];
};

#endif
```

```
---------------- 3:Game.cpp ------------


#include "Game.h"
#include "Bag.h"
#include <stdlib.h> // rand()

Game::Game()
{
    m_bags[0] = new Bag(0,0);
    m_bags[1] = new Bag(0,1);
    m_bags[2] = new Bag(1,1);
}

Game::~Game()
{
    int i;
    for (i=0; i<3; i++)
        delete m_bags[i];
}

Bag *Game::getABag()
{
    return m_bags[rand()%3];
}
```

Bag Class

```
---------------- 4:Bag.h ----------------


#ifndef BAG_H
#define BAG_H

class Ball;

class Bag
{
public:
    Ball *getABall();
    void putBallsBack();
    Bag(int color1, int color2);
    ~Bag();
private:
    Ball *m_balls[2];
    int m_numberOfBalls;
};

#endif
```

```
---------------- 5:Bag.cpp ----------------


#include "Bag.h"
#include "Ball.h"
#include <stdlib.h> // rand()

Bag::Bag(int color1, int color2)
    : m_numberOfBalls(2)
{
    m_balls[0] = new Ball(color1);
    m_balls[1] = new Ball(color2);
}

Bag::~Bag()
{
    delete m_balls[0];
    delete m_balls[1];
}

```

Bag Class (cont’d)

```
Ball *Bag::getABall()
{
    if (m_numberOfBalls == 0)
        return 0;
    else if (m_numberOfBalls == 1)
    {
        m_numberOfBalls = 0;
        return m_balls[0];
    }
    else
    {
        int iPicked = rand()%2;
        Ball *pickedBall = m_balls[iPicked];
        if (iPicked == 0)
        {
            m_balls[0] = m_balls[1];
            m_balls[1] = pickedBall;
        }
        m_numberOfBalls = 1;
        return pickedBall;
    }
}

void Bag::putBallsBack()
{
    m_numberOfBalls = 2;
}
```

This design and implementation are problematic. When you get a ball from a bag, the ownership of the ball is better naturally transferred.

Ball Class

```
---------------- 6:Ball.h ----------------


#ifndef BALL_H
#define BALL_H

class Ball
{
public:
    bool IsRed();
    Ball(int color);
private:
    int m_redWhite;
};

#endif
```

```
---------------- 7:Ball.cpp ----------------


#include "Ball.h"

Ball::Ball(int color)
: m_redWhite(color)
{
}

bool Ball::IsRed()
{
    if (m_redWhite == 0)
        return true;
    else
        return false;
}
```

main()

```

------------- 1:main.cpp -------------


#include "Game.h"
#include "Bag.h"
#include "Ball.h"
#include <stdlib.h> // srand()
#include <time.h> // time()
#include <iostream.h>

void main()
{
    int   i;
    Game  theGame;
    Bag  *pickedBag;
    Ball *pickedBall;
    int   totalCount = 0;
    int   secondIsAlsoRed = 0;

    srand(time(0));

    for (i=0; i<100000; i++)
    {
        pickedBag = theGame.getABag();
        pickedBall = pickedBag–>getABall();
        if (pickedBall–>IsRed())
        {
            totalCount++;
            if (pickedBag–>getABall()–>IsRed())
                secondIsAlsoRed++;
        }
        pickedBag–>putBallsBack();
    }

    cout << "The probability that remaining ball is red = "
     << ((double)secondIsAlsoRed/totalCount) << "\n";
}


```

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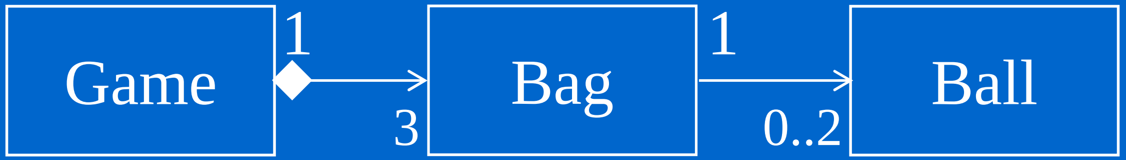

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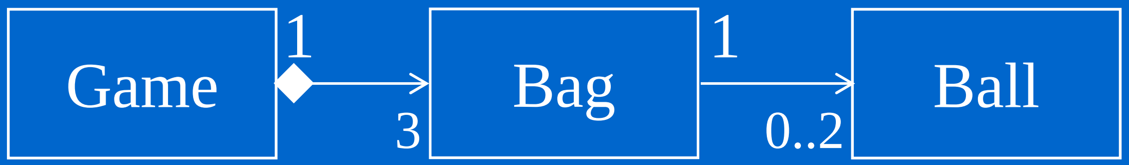

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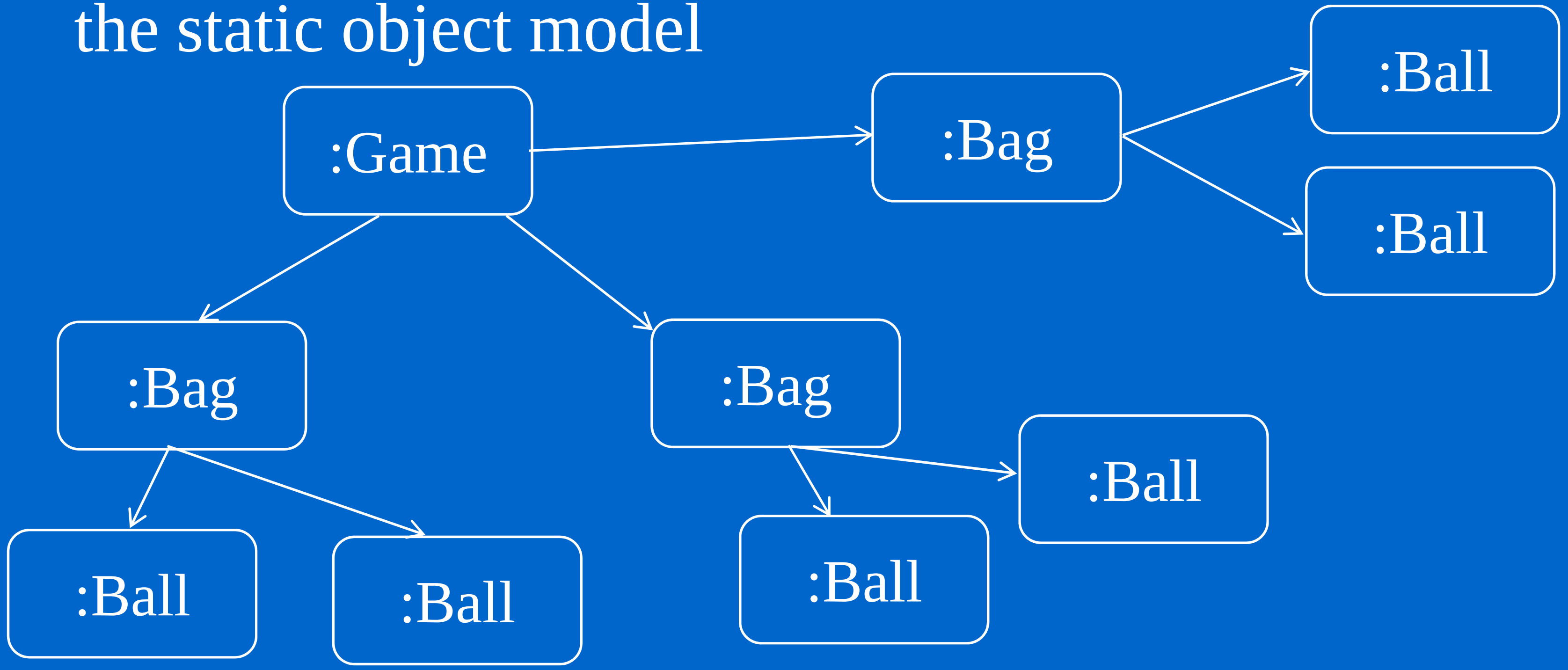

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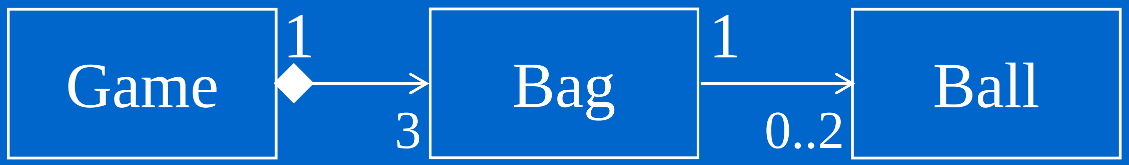

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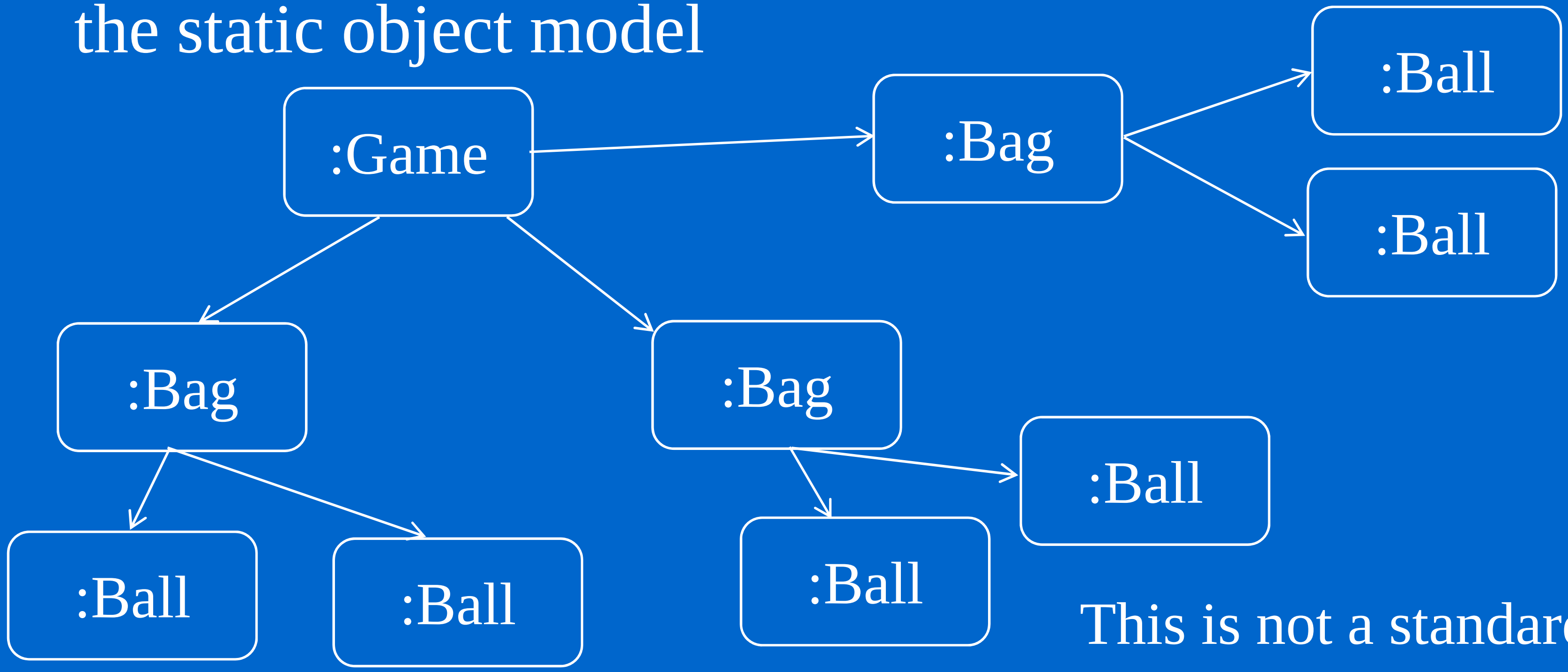

This is not a standard graph.

More Observations

- Bottom-up design: some of the functions of an object might not even be used in this particular application. Ex. the Complex class in the lab
- The functions and data of each class/object are self-contained.
- The *data coupling* and *control coupling* between an object and other objects are designed to be minimal. Objects interact with each other through constrained interface functions.
- Software operations mimic the physical functions of the original real world problem.
- The overall program functionalities are provided by a set of cooperating objects.

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  Ask yourself a question: Is the technology not good to glue everything together as a whole? to make the product more monolithic, more tasteful, more handy, more style of future

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  You are encouraged to browse the OOA, OOD stuffs.