CSE216 Programming Abstractions

Complex Number

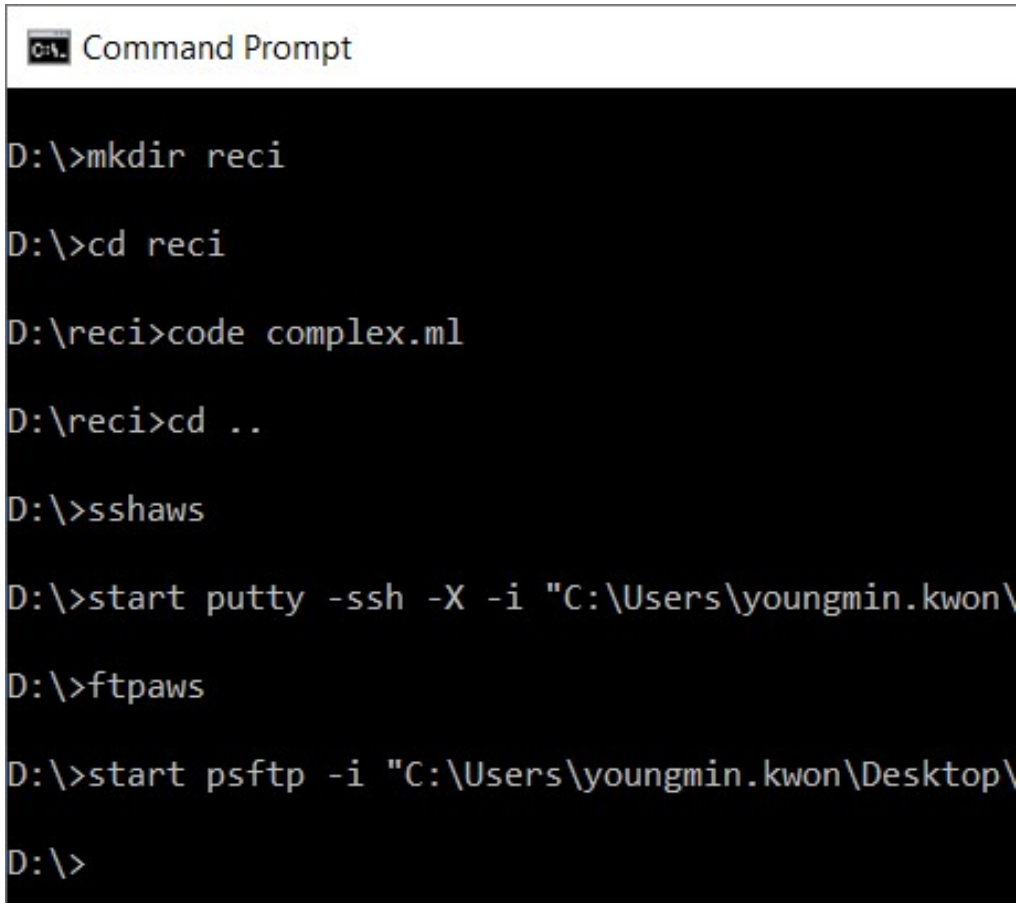
YoungMin Kwon

Using AWS (local machine)

- From your local machine
  - Go to the directory where sshaws, sftpaws are.
  - Create a directory: mkdir <name of a directory>
  - Change directory: cd <name of the directory>
    - .. is the name of the parent directory
    - E.g.) cd ..
  - Run sshaws to run a shell at AWS
  - Run sftpaws to upload/download files to/from AWS

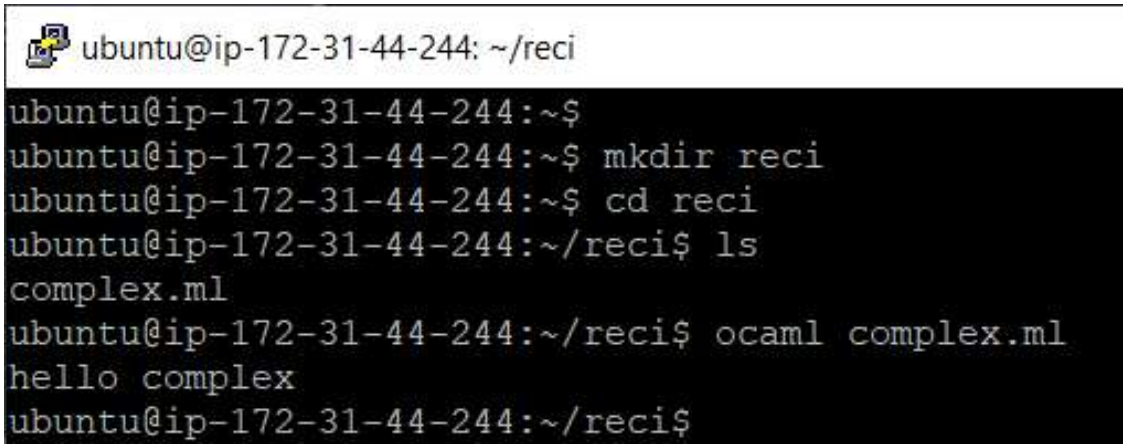
Using AWS (local machine)

- Windows cmd example



Using AWS (ssh)

- In your ssh shell
  - Create a directory: mkdir <name of a directory>
  - Change directory: cd <name of the directory>
  - To see the contents of the directory: ls
  - To run ocaml: ocaml

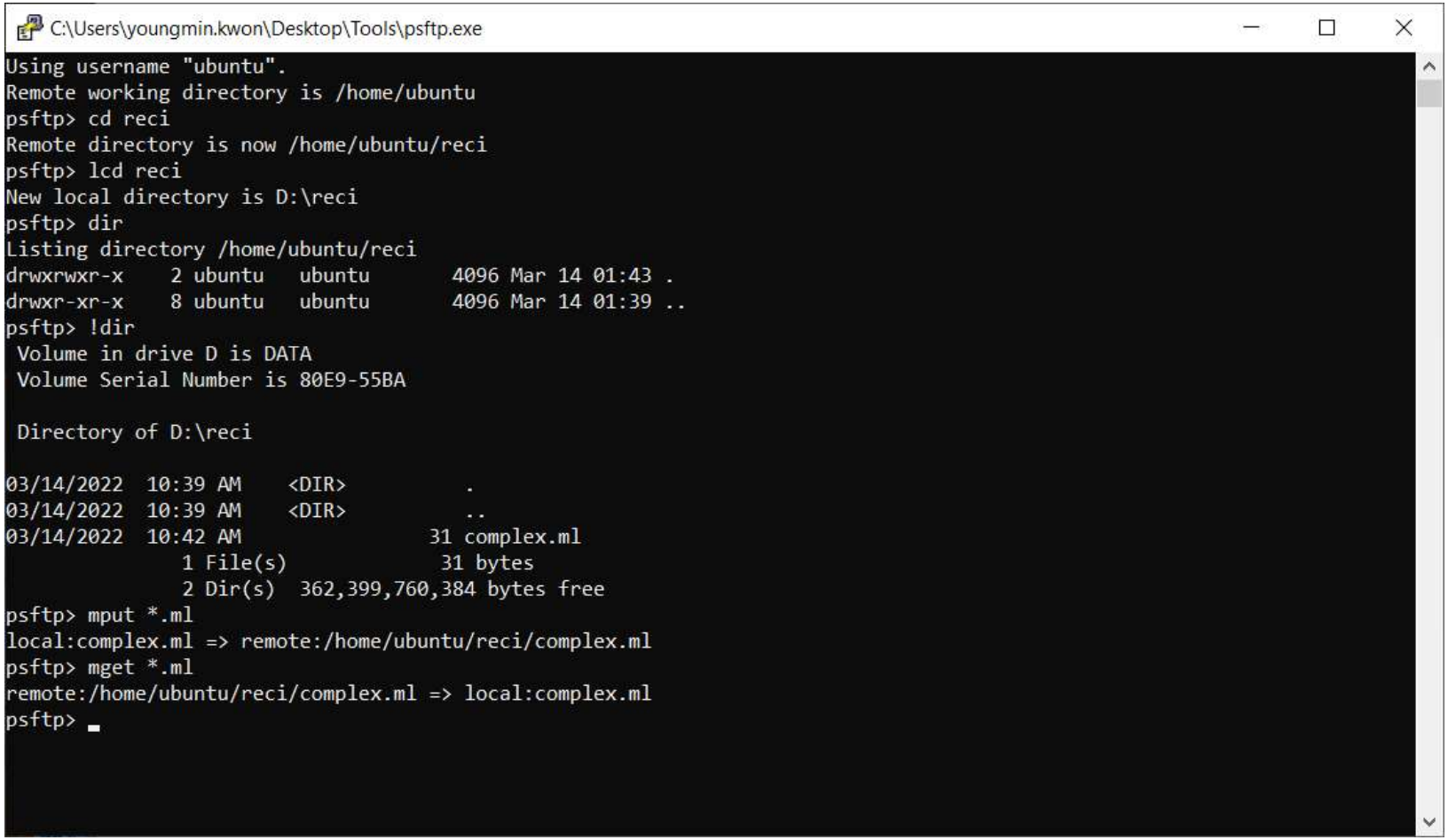


Using AWS (sftp)

- In your sftp shell
  - Change AWS directory: cd <name of directory>
  - Change local directory: lcd <name of directory>
  - To see the contents of AWS directory: dir
  - To see the contents of local directory: !dir
    - To run any local command use !command
  - To upload file: put <file name> or mput *.ml
  - To download file: get <file name> or mget *.ml

Using AWS (sftp)

- sftp



Using Functions Like Objects

- Constructor
  - Takes fields as parameters
  - Return a function that takes a select parameter
- Accessor
  - Depending on the select value, return different values

Using Functions Like Objects

```
(*pair.ml
  In the toplevel run #use "pair.ml";;
*)

(*pair takes f and s as its fields
  depending on sel, return different values
*)
let pair f s =
    fun sel -> if      sel = "first"  then f
               else if sel = "second" then s
               else assert false

(*making an object*)
let a = pair 1 2

(*accessing its fields*)
let _ = a "first"
let _ = a "second"
```

Complex Number

- Constructor
  - complex r i: takes real and imaginary parts and returns a function
- Accessor
  - The function takes a parameter sel and returns its real, imag., mag., and ang. depending on sel.
  - i.e. if c = complex r i, then c sel returns
    - `r` if sel is "real"
    - `i` if sel is "imag"
    - `sqrt (r*r + i*i)` if sel is "mag"
    - `atan2 i r` if sel is "ang"

```
(*constructor and accessor*)
(*sel is one of "real", "imag", "mag", and "ang"*)
let complex r i = (*TODO: implement this function*)
    fun sel ->


(*test*)
let equ a b =
    let eps = 1e-10 in
    let abs x = if x < 0. then -. x else x in
    abs (a -. b) < eps

let a = complex 2. 3.
let b = complex 1. 1.

let test () =
    let ( == ) = equ in
    assert (a "real" == 2.      && a "imag" == 3.);
    assert (b "mag" == sqrt 2. && b "ang" == atan2 1. 1.);
    ()
let _ = test ()

(*
```

Arithmetic Operations

$$(a+bi)+(c+di) = (a+c)+(b+d)i$$

$$(a+bi)-(c+di) = (a-c)+(b-d)i$$

$$(a+bi)*(c+di) = (ac-bd)+(ad+bc)i$$

$$(a+bi)\div(c+di) = \frac{(a+bi)*(\overline{c+di})}{(c+di)*(\overline{c+di})}$$

$$= \frac{ac+bd}{c^2+d^2}+\frac{bc-ad}{c^2+d^2}i$$

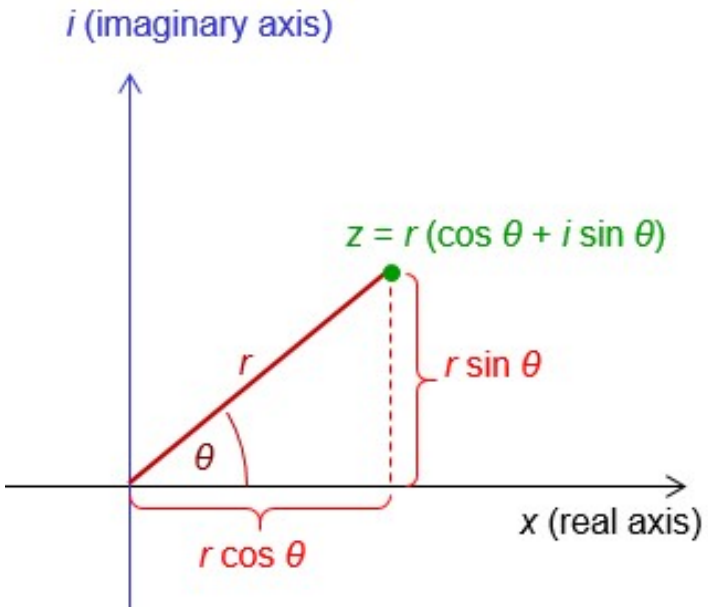
$$(\overline{a+bi}) = (a-bi)$$

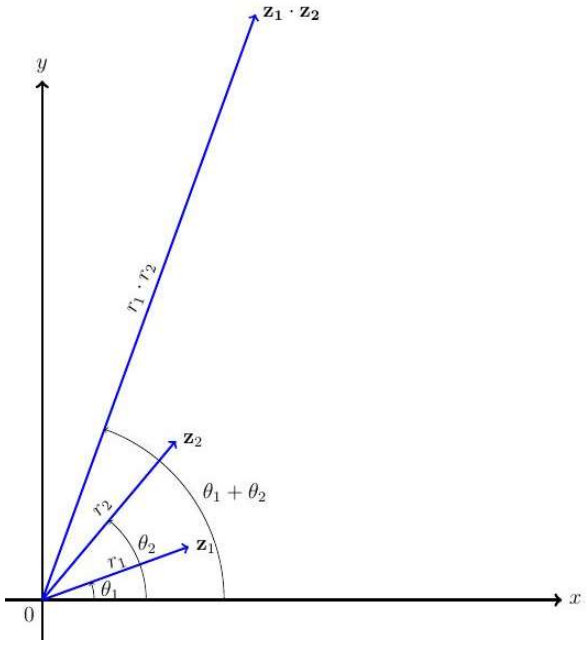
```
(*arithmetic operations*)
(*opr is one of "add", "sub", "mul", and "div"*)
let rec arith opr a b =
    (a "real", a "imag", b "real", b "imag") |> fun (ra, ia, rb, ib) ->
        if      opr = "add" then (*TODO: implement this part*)

        else if opr = "sub" then (*TODO: implement this part*)

        else if opr = "mul" then (*TODO: implement this part*)

        else if opr = "div" then (*TODO: implement this part*)
            let c = complex rb (-. ib) in (*conjugate of b*)
            let (rnum, inum) = arith "mul" a c
                               |> fun num -> (num "real", num "imag") in
            let rden         = arith "mul" b c
                               |> fun den -> den "real" in

        else assert false
```

```
let test () =
    let ( + ) = arith "add" in
    let ( - ) = arith "sub" in
    let ( * ) = arith "mul" in
    let ( / ) = arith "div" in
    let ( == ) = equ in

    a + b |> fun c -> assert (c "real" == 3.  && c "imag" == 4.);
    a - b |> fun c -> assert (c "real" == 1.  && c "imag" == 2.);
    a * b |> fun c -> assert (c "real" == -1. && c "imag" == 5.);
    a / b |> fun c -> assert (c "real" == 2.5 && c "imag" == 0.5);
    ()

let _ = test ()
```

Polar Form

- Multiplication in Polar form





$r \angle \theta = r \cdot \cos\theta + i \cdot r \cdot \sin\theta$

$r_1 \angle \theta_1 \cdot r_2 \angle \theta_2 = (r_1 \cdot r_2) \angle (\theta_1 + \theta_2)$

$r_1 \angle \theta_1 / r_2 \angle \theta_2 = (r_1 / r_2) \angle (\theta_1 - \theta_2)$

```
(*ploar form*)
(*sel is one of "real", "imag", "mag", and "ang"*)
let polar m a =
    fun sel -> (*TODO: implement this function*)


let test () =
    let ( == ) = equ in
    let c = polar (a "mag") (a "ang") in
    assert (c "mag" == a "mag" && c "ang" == a "ang");
    assert (c "real" == 2.     && c "imag" == 3.);
    ()


let _ = test ()
```

```
(*arithmetic operations*)
(*opr is one of "add", "sub", "mul", and "div"*)
let arith2 opr a b =
    (a "mag", a "ang", b "mag", b "ang") |> fun (ma, aa, mb, ab) ->
        (*TODO: implement this function*)

let test () =
    let ( + ) = arith2 "add" in
    let ( - ) = arith2 "sub" in
    let ( * ) = arith2 "mul" in
    let ( / ) = arith2 "div" in
    let ( == ) = equ in
    a + b |> fun c -> assert (c "real" == 3.  && c "imag" == 4.);
    a - b |> fun c -> assert (c "real" == 1.  && c "imag" == 2.);
    a * b |> fun c -> assert (c "real" == -1. && c "imag" == 5.);
    a / b |> fun c -> assert (c "real" == 2.5 && c "imag" == 0.5);
    ()
let _ = test ()
```