A SMALL TYPED DATABASE (35/35 points)

The code of the mini-database example is given in the prelude.

1. You may have noticed that there is an error in the implementation of our database. This error leads to not finding users that should be in the database (because they have been added at some point, and not deleted since) after certain sequences of queries.
   Find the bug and give a sequence of operations `proof_of_bug` of type `query array` that exhibits it when executed one after the other on an initially empty database.
   The failure must be triggered by the last query.
2. To fix this bug, write a new version of `delete` that enforces the following invariant on the database, which is expected by the other functions.
   All the contacts of a database `db` (and no others) should be stored in the array `db.contacts` between indexes `0` and `db.number_of_contacts - 1` (inclusive).
3. Write a new function `update : database -> contact -> (bool * database * contact)` that either changes the number of an existing person or inserts a new contact. It should return `true` and the updated database if any of these two options succeeded, or `false` with the untouched database. The returned `contact` is not important, it is here just so the function has the same signature as the others.
4. Write an updated `engine` function that does an update when given a query with code 3, and uses your updated `delete` function.

THE GIVEN PRELUDE

```
(* A contact has a name and a phone number. *)
type contact = {
  name         : string;
  phone_number : phone_number
};;

(* Here is a dumb contact. *)
let nobody = { name = ""; phone_number = (0, 0, 0, 0) };;

(* A database is a collection of contacts. *)
type database = {
  number_of_contacts : int;
  contacts : contact array;
};;

(* [make n] is the database with no contact and at most [n] contacts
    stored inside. *)
let make max_number_of_contacts =
  {
    number_of_contacts = 0;
    contacts = Array.make max_number_of_contacts nobody
  };;

(* Queries are represented by a code and a contact.
   - If the code is 0 then the contact must be inserted.
   - If the code is 1 then the contact must be deleted.
   - If the code is 2 then we are looking for a contact
     with the same name in the database. *)
type query = {
  code    : int;
  contact : contact;
}

let search db contact =
  let rec aux idx =
    if idx >= db.number_of_contacts then
      (false, db, nobody)
    else if db.contacts.(idx).name = contact.name then
      (true, db, db.contacts.(idx))
    else
      aux (idx + 1)
  in
  aux 0;;

let insert db contact =
  if db.number_of_contacts >= Array.length db.contacts then
    (false, db, nobody)
  else
    let (status, db, _) = search db contact in
    if status then (false, db, contact) else
      let cells i =
        if i = db.number_of_contacts then contact else db.contacts.(i)
      in
      let db' = {
          number_of_contacts = db.number_of_contacts + 1;
          contacts = Array.init (Array.length db.contacts) cells
        }
      in
      (true, db', contact);;

let delete db contact =
  let (status, db, contact) = search db contact in
  if not status then (false, db, contact)
  else
    let cells i =
      if db.contacts.(i).name = contact.name then
        nobody
      else
```

```
        contacts = Array.init (Array.length db.contacts) cells
      }
    in
    (true, db', contact);;

(* Engine parses and interprets the query. *)
let engine db { code ; contact } =
  if code = 0 then insert db contact
  else if code = 1 then delete db contact
  else if code = 2 then search db contact
  else (false, db, nobody);;
```

YOUR OCAML ENVIRONMENT

```
let proof_of_bug =
  [|
    { code = 0; contact = { name = "luke"; phone_number = (4, 3, 2, 1) } } ;
    { code = 0; contact = { name = "darth"; phone_number = (4, 3, 2, 1) } } ;
    { code = 1; contact = { name = "luke"; phone_number = (4, 3, 2, 1) } } ;
    { code = 2; contact = { name = "darth"; phone_number = (4, 3, 2, 1) } } ;
  |]
;;
(* il efface le dernier *)

let delete db contact =
  let (status, db, contact) = search db contact in
  if not status then (false, db, contact)
  else
    let cells i =
      if db.contacts.(i).name = contact.name then
        db.contacts.(db.number_of_contacts - 1)
      else db.contacts.(i)
    in
    let db' = {
      number_of_contacts = db.number_of_contacts - 1;
      contacts = Array.init (Array.length db.contacts) cells
    }
    in
    (true, db', contact)
;;

let update db contact =
  let (status, db, _) = search db contact in
  if not status then insert db contact else
    let cells i =
      if db.contacts.(i).name = contact.name then
        contact
```

Evaluate >

Switch >>

Typecheck

Reset Templ

Full-screen

Check & Sa

Exercise complete (click for details) 35 pts

v Exercise 1: proof_of_bug — Completed, 5 pts

Found proof_of_bug with compatible type.

Congratulations, your sequence exhibits the bug! — 5 pts

v Exercise 2: corrected delete — Completed, 10 pts

Found delete with compatible type.

```
Computing
  delete
    {number_of_contacts = 0; contacts = [||]}
    {name = "Yannto"; phone_number = (4, 8, 6, 10)}
Correct value                                                       1 pt
  (false, {number_of_contacts = 0; contacts = [||]},
   {name = ""; phone_number = (0, 0, 0, 0)})
Computing
  delete
    {number_of_contacts = 4;
     contacts =
      [|{name = "Greyann"; phone_number = (18, 3, 6, 7)};
        {name = "Benralf"; phone_number = (9, 17, 6, 4)};
        {name = "Mingre"; phone_number = (0, 12, 6, 1)};
        {name = "Dasgoire"; phone_number = (14, 7, 6, 15)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {name = "Berja"; phone_number = (5, 2, 6, 12)}
Correct value                                                       1 pt
  (false,
   {number_of_contacts = 4;
    contacts =
     [|{name = "Greyann"; phone_number = (18, 3, 6, 7)};
       {name = "Benralf"; phone_number = (9, 17, 6, 4)};
       {name = "Mingre"; phone_number = (0, 12, 6, 1)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = ""; phone_number = (0, 0, 0, 0)})
Computing
  delete
    {number_of_contacts = 2;
     contacts =
      [|{name = "Yannmin"; phone_number = (19, 16, 6, 9)};
        {name = "Grecag"; phone_number = (10, 11, 6, 6)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {name = "Grecag"; phone_number = (10, 11, 6, 6)}
Correct value                                                                1 pt
  (true,
   {number_of_contacts = 1;
    contacts =
     [|{name = "Yannmin"; phone_number = (19, 16, 6, 9)};
       {name = "Grecag"; phone_number = (10, 11, 6, 6)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = "Grecag"; phone_number = (10, 11, 6, 6)})
Computing
  delete
    {number_of_contacts = 2;
     contacts =
      [|{name = "Bendas"; phone_number = (1, 6, 6, 3)};
        {name = "Minrober"; phone_number = (15, 1, 6, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {name = "Dasberber"; phone_number = (6, 15, 6, 14)}
Correct value                                                                1 pt
  (false,
   {number_of_contacts = 2;
    contacts =
     [|{name = "Bendas"; phone_number = (1, 6, 6, 3)};
       {name = "Minrober"; phone_number = (15, 1, 6, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = ""; phone_number = (0, 0, 0, 0)})
Computing
  delete
    {number_of_contacts = 7;
     contacts =
      [|{name = "Beryannber"; phone_number = (20, 10, 6, 11)};
        {name = "Yannralfber"; phone_number = (11, 5, 6, 8)};
        {name = "Gregreber"; phone_number = (2, 0, 6, 5)};
        {name = "Bengoireber"; phone_number = (16, 14, 6, 2)};
        {name = "Minbenber"; phone_number = (7, 9, 6, 16)};
        {name = "Dasjaber"; phone_number = (21, 4, 6, 13)};
        {name = "Bercagber"; phone_number = (12, 18, 6, 10)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {name = "Bercagber"; phone_number = (12, 18, 6, 10)}
Correct value                                                                1 pt
  (true,
   {number_of_contacts = 6;
    contacts =
     [|{name = "Beryannber"; phone_number = (20, 10, 6, 11)};
       {name = "Yannralfber"; phone_number = (11, 5, 6, 8)};
       {name = "Gregreber"; phone_number = (2, 0, 6, 5)};
       {name = "Bengoireber"; phone_number = (16, 14, 6, 2)};
       {name = "Minbenber"; phone_number = (7, 9, 6, 16)};
       {name = "Dasjaber"; phone_number = (21, 4, 6, 13)};
       {name = "Bercagber"; phone_number = (12, 18, 6, 10)};
```

```
Computing
  delete
    {number_of_contacts = 0;
     contacts =
      [|{name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {name = "Yanndasber"; phone_number = (3, 13, 6, 7)}
Correct value                                                      1 pt
  (false,
   {number_of_contacts = 0;
    contacts =
     [|{name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = ""; phone_number = (0, 0, 0, 0)})
Computing
  delete
    {number_of_contacts = 2;
     contacts =
      [|{name = "Greroto"; phone_number = (17, 8, 6, 4)};
        {name = "Benberto"; phone_number = (8, 3, 6, 1)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {name = "Mintoto"; phone_number = (22, 17, 6, 15)}
Correct value                                                      1 pt
  (false,
   {number_of_contacts = 2;
    contacts =
     [|{name = "Greroto"; phone_number = (17, 8, 6, 4)};
       {name = "Benberto"; phone_number = (8, 3, 6, 1)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = ""; phone_number = (0, 0, 0, 0)})
Computing
  delete
    {number_of_contacts = 0;
     contacts =
      [|{name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {name = "Dasyannto"; phone_number = (13, 12, 6, 12)}
Correct value                                                      1 pt
  (false,
   {number_of_contacts = 0;
    contacts =
     [|{name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = ""; phone_number = (0, 0, 0, 0)})
Computing
  delete
    {number_of_contacts = 7;
     contacts =
      [|{name = "Bergreto"; phone_number = (4, 7, 6, 9)};
        {name = "Yanngoireto"; phone_number = (18, 2, 6, 6)};
        {name = "Grebento"; phone_number = (9, 16, 6, 3)};
        {name = "Benjato"; phone_number = (0, 11, 6, 0)};
        {name = "Minminto"; phone_number = (14, 6, 6, 14)};
        {name = "Dascagto"; phone_number = (5, 1, 6, 11)};
        {name = "Berroyann"; phone_number = (19, 15, 6, 8)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {name = "Bergreto"; phone_number = (4, 7, 6, 9)}
Correct value                                                      1 pt
  (true,
   {number_of_contacts = 6;
    contacts =
     [|{name = "Berroyann"; phone_number = (19, 15, 6, 8)};
       {name = "Yanngoireto"; phone_number = (18, 2, 6, 6)};
       {name = "Grebento"; phone_number = (9, 16, 6, 3)};
       {name = "Benjato"; phone_number = (0, 11, 6, 0)};
       {name = "Minminto"; phone_number = (14, 6, 6, 14)};
       {name = "Dascagto"; phone_number = (5, 1, 6, 11)};
       {name = "Berroyann"; phone_number = (19, 15, 6, 8)};
```

Computing

```
  delete
    {number_of_contacts = 3;
     contacts =
      [|{name = "Yannberyann"; phone_number = (10, 10, 6, 5)};
        {name = "Gretoyann"; phone_number = (1, 5, 6, 2)};
        {name = "Benyannyann"; phone_number = (15, 0, 6, 16)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {name = "Yannberyann"; phone_number = (10, 10, 6, 5)}
```

Correct value 1 pt

```
  (true,
   {number_of_contacts = 2;
    contacts =
     [|{name = "Benyannyann"; phone_number = (15, 0, 6, 16)};
       {name = "Gretoyann"; phone_number = (1, 5, 6, 2)};
       {name = "Benyannyann"; phone_number = (15, 0, 6, 16)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = "Yannberyann"; phone_number = (10, 10, 6, 5)})
```

v Exercise 3: `update` Completed, 10 pts

Found `update` with compatible type.

Computing

```
  update
    {number_of_contacts = 0; contacts = [||]}
    {name = "Minralfyann"; phone_number = (6, 14, 6, 13)}
```

Correct value 1 pt

```
  (false, {number_of_contacts = 0; contacts = [||]},
   {name = ""; phone_number = (0, 0, 0, 0)})
```

Computing

```
  update
    {number_of_contacts = 0;
     contacts =
      [|{name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {name = "Dasgreyann"; phone_number = (20, 9, 6, 10)}
```

Correct value 1 pt

```
  (true,
   {number_of_contacts = 1;
    contacts =
     [|{name = "Dasgreyann"; phone_number = (20, 9, 6, 10)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = "Dasgreyann"; phone_number = (20, 9, 6, 10)})
```

Computing

```
  update
    {number_of_contacts = 2;
     contacts =
      [|{name = "Berbenyann"; phone_number = (11, 4, 6, 7)};
        {name = "Yannjayann"; phone_number = (2, 18, 6, 4)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {name = "Berbenyann"; phone_number = (16, 13, 6, 1)}
```

Correct value 1 pt

```
  (true,
   {number_of_contacts = 2;
    contacts =
     [|{name = "Berbenyann"; phone_number = (16, 13, 6, 1)};
       {name = "Yannjayann"; phone_number = (2, 18, 6, 4)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = "Berbenyann"; phone_number = (16, 13, 6, 1)})
```

Computing

```
  update
    {number_of_contacts = 1;
     contacts =
      [|{name = "Bencagyann"; phone_number = (7, 8, 6, 15)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {name = "Mindasyann"; phone_number = (21, 3, 6, 12)}
```

Correct value 1 pt

```
  (true,
   {number_of_contacts = 2;
    contacts =
     [|{name = "Bencagyann"; phone_number = (7, 8, 6, 15)};
       {name = "Mindasyann"; phone_number = (21, 3, 6, 12)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = "Mindasyann"; phone_number = (21, 3, 6, 12)})
```

Computing

```
        {name = "Bertoralf"; phone_number = (3, 12, 6, 6)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {name = "Yannyannralf"; phone_number = (17, 7, 6, 3)}
Correct value                                                          1 pt
  (true,
   {number_of_contacts = 3;
    contacts =
     [|{name = "Dasroralf"; phone_number = (12, 17, 6, 9)};
       {name = "Bertoralf"; phone_number = (3, 12, 6, 6)};
       {name = "Yannyannralf"; phone_number = (17, 7, 6, 3)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = "Yannyannralf"; phone_number = (17, 7, 6, 3)})
Computing
  update
    {number_of_contacts = 4;
     contacts =
      [|{name = "Greralfralf"; phone_number = (8, 2, 6, 0)};
        {name = "Bengreralf"; phone_number = (22, 16, 6, 14)};
        {name = "Mingoireralf"; phone_number = (13, 11, 6, 11)};
        {name = "Dasbenralf"; phone_number = (4, 6, 6, 8)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {name = "Bengreralf"; phone_number = (18, 1, 6, 5)}
Correct value                                                          1 pt
  (true,
   {number_of_contacts = 4;
    contacts =
     [|{name = "Greralfralf"; phone_number = (8, 2, 6, 0)};
       {name = "Bengreralf"; phone_number = (18, 1, 6, 5)};
       {name = "Mingoireralf"; phone_number = (13, 11, 6, 11)};
       {name = "Dasbenralf"; phone_number = (4, 6, 6, 8)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = "Bengreralf"; phone_number = (18, 1, 6, 5)})
Computing
  update
    {number_of_contacts = 0;
     contacts =
      [|{name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {name = "Yanncagralf"; phone_number = (9, 15, 6, 2)}
Correct value                                                          1 pt
  (true,
   {number_of_contacts = 1;
    contacts =
     [|{name = "Yanncagralf"; phone_number = (9, 15, 6, 2)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = "Yanncagralf"; phone_number = (9, 15, 6, 2)})
Computing
  update
    {number_of_contacts = 1;
     contacts =
      [|{name = "Gredasralf"; phone_number = (0, 10, 6, 16)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {name = "Gredasralf"; phone_number = (14, 5, 6, 13)}
Correct value                                                          1 pt
  (true,
   {number_of_contacts = 1;
    contacts =
     [|{name = "Gredasralf"; phone_number = (14, 5, 6, 13)};
     {name = ""; phone_number = (0, 0, 0, 0)}|]},
  {name = "Gredasralf"; phone_number = (14, 5, 6, 13)})
```

Computing

```
  update
    {number_of_contacts = 1;
     contacts =
      [|{name = "Minbergre"; phone_number = (5, 0, 6, 10)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {name = "Minbergre"; phone_number = (19, 14, 6, 7)}
```

Correct value 1 pt

```
  (true,
   {number_of_contacts = 1;
    contacts =
     [|{name = "Minbergre"; phone_number = (19, 14, 6, 7)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = "Minbergre"; phone_number = (19, 14, 6, 7)})
```

Computing

```
  update
    {number_of_contacts = 6;
     contacts =
      [|{name = "Berralfgre"; phone_number = (10, 9, 6, 4)};
        {name = "Yanngregre"; phone_number = (1, 4, 6, 1)};
        {name = "Gregoiregre"; phone_number = (15, 18, 6, 15)};
        {name = "Benbengre"; phone_number = (6, 13, 6, 12)};
        {name = "Minjagre"; phone_number = (20, 8, 6, 9)};
        {name = "Dasmingre"; phone_number = (11, 3, 6, 6)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {name = "Berdasgre"; phone_number = (2, 17, 6, 3)}
```

Correct value 1 pt

```
  (true,
   {number_of_contacts = 7;
    contacts =
     [|{name = "Berralfgre"; phone_number = (10, 9, 6, 4)};
       {name = "Yanngregre"; phone_number = (1, 4, 6, 1)};
       {name = "Gregoiregre"; phone_number = (15, 18, 6, 15)};
       {name = "Benbengre"; phone_number = (6, 13, 6, 12)};
       {name = "Minjagre"; phone_number = (20, 8, 6, 9)};
       {name = "Dasmingre"; phone_number = (11, 3, 6, 6)};
       {name = "Berdasgre"; phone_number = (2, 17, 6, 3)}|]},
   {name = "Berdasgre"; phone_number = (2, 17, 6, 3)})
```

v Exercise 4: upgraded engine Completed, 10 pts

Found engine with compatible type.

Computing

```
  engine
    {number_of_contacts = 7;
     contacts =
      [|{name = "Yannrogoire"; phone_number = (16, 12, 6, 0)};
        {name = "Grebergoire"; phone_number = (7, 7, 6, 14)};
        {name = "Bentogoire"; phone_number = (21, 2, 6, 11)};
        {name = "Minyanngoire"; phone_number = (12, 16, 6, 8)};
        {name = "Dasralfgoire"; phone_number = (3, 11, 6, 5)};
        {name = "Bergoiregoire"; phone_number = (17, 6, 6, 2)};
        {name = "Yannbengoire"; phone_number = (8, 1, 6, 16)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {code = 3;
     contact = {name = "Grebergoire"; phone_number = (22, 15, 6, 13)}}
```

Correct value 1 pt

```
  (true,
   {number_of_contacts = 7;
    contacts =
     [|{name = "Yannrogoire"; phone_number = (16, 12, 6, 0)};
       {name = "Grebergoire"; phone_number = (22, 15, 6, 13)};
       {name = "Bentogoire"; phone_number = (21, 2, 6, 11)};
       {name = "Minyanngoire"; phone_number = (12, 16, 6, 8)};
       {name = "Dasralfgoire"; phone_number = (3, 11, 6, 5)};
       {name = "Bergoiregoire"; phone_number = (17, 6, 6, 2)};
       {name = "Yannbengoire"; phone_number = (8, 1, 6, 16)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = "Grebergoire"; phone_number = (22, 15, 6, 13)})
```

Computing

```
  engine
    {number_of_contacts = 6;
     contacts =
      [|{name = "Benmingoire"; phone_number = (13, 10, 6, 10)};
        {name = "Mincaggoire"; phone_number = (4, 5, 6, 7)};
        {name = "Dasdasgoire"; phone_number = (18, 0, 6, 4)};
        {name = "Berberben"; phone_number = (9, 14, 6, 1)};
        {name = "Yanntoben"; phone_number = (0, 9, 6, 15)};
        {name = "Greyannben"; phone_number = (14, 4, 6, 12)};
        {name = ""; phone_number = (0, 0, 0, 0)};
```

Correct value 1 pt

```
  (true,
   {number_of_contacts = 5;
    contacts =
     [|{name = "Greyannben"; phone_number = (14, 4, 6, 12)};
       {name = "Mincaggoire"; phone_number = (4, 5, 6, 7)};
       {name = "Dasdasgoire"; phone_number = (18, 0, 6, 4)};
       {name = "Berberben"; phone_number = (9, 14, 6, 1)};
       {name = "Yanntoben"; phone_number = (0, 9, 6, 15)};
       {name = "Greyannben"; phone_number = (14, 4, 6, 12)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = "Benmingoire"; phone_number = (13, 10, 6, 10)})
```

Computing

```
  engine
    {number_of_contacts = 1;
     contacts =
      [|{name = "Mingreben"; phone_number = (19, 13, 6, 6)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {code = 1; contact = {name = "Dasgoireben"; phone_number = (10, 8, 6, 3)}}
```

Correct value 1 pt

```
  (false,
   {number_of_contacts = 1;
    contacts =
     [|{name = "Mingreben"; phone_number = (19, 13, 6, 6)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = ""; phone_number = (0, 0, 0, 0)})
```

Computing

```
  engine
    {number_of_contacts = 2;
     contacts =
      [|{name = "Berjaben"; phone_number = (1, 3, 6, 0)};
        {name = "Yannminben"; phone_number = (15, 17, 6, 14)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {code = 1; contact = {name = "Grecagben"; phone_number = (6, 12, 6, 11)}}
```

Correct value 1 pt

```
  (false,
   {number_of_contacts = 2;
    contacts =
     [|{name = "Berjaben"; phone_number = (1, 3, 6, 0)};
       {name = "Yannminben"; phone_number = (15, 17, 6, 14)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = ""; phone_number = (0, 0, 0, 0)})
```

Computing

```
  engine
    {number_of_contacts = 4;
     contacts =
      [|{name = "Bendasben"; phone_number = (20, 7, 6, 8)};
        {name = "Minroja"; phone_number = (11, 2, 6, 5)};
        {name = "Dasberja"; phone_number = (2, 16, 6, 2)};
        {name = "Beryannja"; phone_number = (16, 11, 6, 16)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {code = 1; contact = {name = "Yannralfja"; phone_number = (7, 6, 6, 13)}}
```

Correct value 1 pt

```
  (false,
   {number_of_contacts = 4;
    contacts =
     [|{name = "Bendasben"; phone_number = (20, 7, 6, 8)};
       {name = "Minroja"; phone_number = (11, 2, 6, 5)};
       {name = "Dasberja"; phone_number = (2, 16, 6, 2)};
       {name = "Beryannja"; phone_number = (16, 11, 6, 16)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = ""; phone_number = (0, 0, 0, 0)})
```

Computing

```
      [|{name = "Gregreja"; phone_number = (21, 1, 6, 10)};
        {name = "Bengoireja"; phone_number = (12, 15, 6, 7)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {code = 2; contact = {name = "Gregreja"; phone_number = (3, 10, 6, 4)}}
```

Correct value 1 pt

```
  (true,
   {number_of_contacts = 2;
    contacts =
     [|{name = "Gregreja"; phone_number = (21, 1, 6, 10)};
       {name = "Bengoireja"; phone_number = (12, 15, 6, 7)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = "Gregreja"; phone_number = (21, 1, 6, 10)})
```

Computing

```
  engine
    {number_of_contacts = 4;
     contacts =
      [|{name = "Dasjaja"; phone_number = (17, 5, 6, 1)};
        {name = "Bercagja"; phone_number = (8, 0, 6, 15)};
        {name = "Yanndasja"; phone_number = (22, 14, 6, 12)};
        {name = "Greromin"; phone_number = (13, 9, 6, 9)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {code = 1; contact = {name = "Benbermin"; phone_number = (4, 4, 6, 6)}}
```

Correct value 1 pt

```
  (false,
   {number_of_contacts = 4;
    contacts =
     [|{name = "Dasjaja"; phone_number = (17, 5, 6, 1)};
       {name = "Bercagja"; phone_number = (8, 0, 6, 15)};
       {name = "Yanndasja"; phone_number = (22, 14, 6, 12)};
       {name = "Greromin"; phone_number = (13, 9, 6, 9)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = ""; phone_number = (0, 0, 0, 0)})
```

Computing

```
  engine
    {number_of_contacts = 4;
     contacts =
      [|{name = "Mintomin"; phone_number = (18, 18, 6, 3)};
        {name = "Dasyannmin"; phone_number = (9, 13, 6, 0)};
        {name = "Bergremin"; phone_number = (0, 8, 6, 14)};
        {name = "Yanngoiremin"; phone_number = (14, 3, 6, 11)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {code = 1; contact = {name = "Grebenmin"; phone_number = (5, 17, 6, 8)}}
```

Correct value 1 pt

```
  (false,
   {number_of_contacts = 4;
    contacts =
     [|{name = "Mintomin"; phone_number = (18, 18, 6, 3)};
       {name = "Dasyannmin"; phone_number = (9, 13, 6, 0)};
       {name = "Bergremin"; phone_number = (0, 8, 6, 14)};
       {name = "Yanngoiremin"; phone_number = (14, 3, 6, 11)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = ""; phone_number = (0, 0, 0, 0)})
```

Computing

```
  engine
    {number_of_contacts = 2;
     contacts =
      [|{name = "Benjamin"; phone_number = (19, 12, 6, 5)};
        {name = "Minminmin"; phone_number = (10, 7, 6, 2)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {code = 1; contact = {name = "Benjamin"; phone_number = (1, 2, 6, 16)}}
```

Correct value 1 pt

```
  (true,
   {number_of_contacts = 1;
    contacts =
     [|{name = "Minminmin"; phone_number = (10, 7, 6, 2)};
  engine
    {number_of_contacts = 2;
     contacts =
      [|{name = "Berrocag"; phone_number = (15, 16, 6, 13)};
        {name = "Yannbercag"; phone_number = (6, 11, 6, 10)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)};
        {name = ""; phone_number = (0, 0, 0, 0)}|]}
    {code = 1; contact = {name = "Gretocag"; phone_number = (20, 6, 6, 7)}}
```

Correct value 1 pt

```
  (false,
   {number_of_contacts = 2;
    contacts =
     [|{name = "Berrocag"; phone_number = (15, 16, 6, 13)};
       {name = "Yannbercag"; phone_number = (6, 11, 6, 10)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)};
       {name = ""; phone_number = (0, 0, 0, 0)}|]},
   {name = ""; phone_number = (0, 0, 0, 0)})
```