N-M TOTAL PARTICIPATION:

- Employees are **required** to work on at least 1 project.
- Employees can work on multiple projects.
- Projects are not required to have employees.
- Projects can have multiple employees.

N-M OPTIONAL PARTICIPATION:

- Employees are **not required** to work on a project.
- Employees can work on multiple projects.
- Projects are not required to have employees.
- Projects can have multiple employees.

(More Precise Bounds)

- (1,_) means total participation (lower bound = 1)
  [an employee must work on at least 1 project]
- (0,_) means optional participation (lower bound = 0)
  [a project is not required to have employees]
- (_,N) means can participate at most N times
  [an employee can work on up to N projects]
- (_,M) means can participate in relationship M times
  [projects can have up to M employees]
N-1 TOTAL PARTICIPATION:

* Departments **must** belong to a school (== total participation).
* Departments can belong to only one school, while schools can have N departments) - Represent by arrow
* The school is like an attribute of the department because it can have only 1 value, and is a required value

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N-1 OPTIONAL PARTICIPATION:

* Students are not required to have an office (optional)
  • If a student has an office, they can have at most one office (by school policy) - Represent by arrow
* The office is like an attribute of the student, because it can have only 1 value, but it is not efficient because some students do not have offices (empty value)

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(More Precise Bounds)

DEPARTMENT [InSchool] SCHOOL

* (1,_) means total participation (lower bound = 1) [a department must be in a school]
* (0,_) means optional participation (lower bound = 0) [a school is not required to have departments]
* (_,1) means can participate at most 1 time [department can be in at most 1 school]
* (_,N) means can participate in relationship N times [schools can have up to N departments]

STUDENT [WorksIn] OFFICE

* (0,1) means a student can have at most one office, but is not required to have an office.
* (0,20) means an office can be assigned to at most 20 students (by school policy), but is allowed to be empty (have no students assigned)
1-1 TOTAL PARTICIPATION (ONE SIDED TOTAL):

* Departments must be chaired (== total participation).
  • Departments can have only 1 chair
  • Employees are not required to chair (optional participation), but if they do, they can only chair one department
  • The chair is like an attribute of the department because it can have only 1 value, and it is a required value. The reverse, while possible, is very inefficient because most employees are not chairs (so attribute mostly empty)

1-1 OPTIONAL PARTICIPATION (BOTH DIRECTIONS):

• Employees are not required to have cellphones (optional), and a cellphone is not required to be assigned to anyone
  • If an employee has a cellphone, they can have at most one cellphone (by company policy) - Represent by arrow and a cellphone can be used by only one employee
  • The work cellphone could be an attribute of an employee (and vice-versa), but not efficient because often empty

(Equally Precise Bounds)

• (1,_) means total participation (lower bound = 1)
  [a department must have a chair]
• (0,_) means optional participation (lower bound = 0)
  [an employee is not required to be a chair]
• (_,1) means can participate at most 1 time
  [department can have at most 1 chair, and employees can chair at most one department if they are a chair]

• (0,1) means an employee is not required to have a cellphone, but can only have 1 if they do.
  • (0,1) means a cellphone is not required to be assigned to any employee, but if it is, it can only be assigned to a single employee
Every employee is required to have a cellphone, and only one cellphone.

Every cellphone is required to be assigned to an employee (the exactly correct number are leased, and returned if an employee leaves).

Either the cellphone or the employee can be an attribute of each other. Either choice is viable and a matter of perspective. But it is far preferable to have this as a relationship rather than an attribute of both entities given redundancy issues.

(1,1) means an employee is required to have a cellphone, and can only have 1 cellphone

(1,1) means every cellphone is required to be assigned to an employee, and it can be assigned to only 1 employee