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ERP system for a Multinational EcoCity (MEC)

(SELF-SUFFICIENT SUSTAINABLE ECOCITY THAT SPREADS ON SEVERAL COUNTRIES)

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Abstract

The world today is facing an existential threat called climate change; the environment of the world is changing because of human activities.

Most of human activities come from the business sector that provides humans with their needs, unfortunately, that comes on the expense of our planet.

Instead of looking to these problems as separate problems, the concept of MEC (MultiEcoCity) is trying to connect all systems together to create a multi dimensional solution that works together.

To be able to connect all these systems together, we need an ERP (Enterprise Resources Planning) system to be able to make everything works together.

So the objective of this thesis is to create a customized ERP system that can help in building and maintaining an MEC (MultiEcoCity) and its sub projects.

Customized affordable ERP system module was built, details are in this thesis.

The system was stable and customizable, there are number of improvements can be done.

CONTENTS

LIST OF ABBREVIATIONS

CMS: Content Management System

ERP: Enterprise Resources Planning

CRM: Customer Relationship Management

HR: Human Resources

OOP: Object Oriented Programming

PHP: computer language (Hypertext Preprocessor)

MEC / M.E.C: MultiEcoCity

ACF: Advanced Custom Field

ERP Entities:

PO: Purchase Order

SHO: Shop Order

INO: Inventory Order

PRD: Product

LOT: LOT (inventory, a batch of products made or collected together)

USR: User (system user)

COM: Company

DOC: document

PER: Person

EXP: Expense

SRV: Service

1 INTRODUCTION

This is a project to build an ERP system that covers the needs of a MultiEcoCity.

A MultiEcoCity (M.E.C for short) is a multinational organization / holding company that owns several projects around the world to cover the needs for its members / shareholders.

That creates a problem for managing all different projects efficiently using the latest technologies without sacrificing high costs.

To be able to solve this problem, we need to know more about the EcoCity, and then we can try to find solutions for it.

1.1 M.E.C: Business solution to an environmental problem:

The business world is there to serve the needs of humans, destruction of environment is a direct threat to humans, and the main cause of this is the business sector, why is a tool that is suppose to help humans are the main tool to destroy them?

To understand that more, we need to look to the problem from a different angel:

1- Business sector is a system: Profits is its programming language:

Almost all environmental problems of the world come from the business sector, every product and service we use comes from the business sector.

People speak about the responsibility of the business sector of destruction of planet earth as if the business sector is a living thing, it is not: it is a system.

It is a system designed by us to help us to get what we need, and the way of controlling this system is a programming language called profits.

If the commands of this programming language are written to destroy the world, the business sector will - and is doing that - if you change these commands to save the world, it will do that.

2- Can one company do it?

If a new way to do business proved to be more efficient, businesses adapt and use it, if that way of doing business helps the environment, than one example with exceptional results can change a whole industry and the whole world.

Tesla electric cars are just one example of a company that changed a whole sector and the world by proving that: Yes, electric cars can be more profitable than petrol cars.

3- ERP or no ERP

ERP system will be the main tool to help our company reach its goals, but ERP systems are a huge investment, as a startup you can't afford it, but also you can't afford not to have it, so how to solve this problem?

Best solution for this problem was building a custom made ERP system on top of available open source software packages that are well maintained.

The reasons behind this decision are the following:

1- Cost:

Open source software are mostly free of charge, all you need is a good understanding of programming to use them in an effective way.

2- Customization:

Building your own ERP system means you can customize any need without restrictions from the ERP owner company

3-Security:

Using well maintained open source packages will ensure the constant updating and upgrading of systems to keep all systems secured.

4- What are the components of a Multi EcoCity?

Several projects connected together under one umbrella, the main goal of these projects is to create a self-sufficient ecosystem, where members can depend on it to create the green life style they all want, while in the same time it still maintains an economic long term growth and prosperity for the whole system.

The projects are in different sectors in different countries to ensure the stability of the whole system if and when one sector / country faces problems.

5- Why the MultiEcoCity?

Two Main reasons: Environment and Freedom

1- Environment:
The main difference between a MultiEcoCity and a lot of other similar systems is that it is built from the beginning with environment protection as a goal in itself, a goal that can be measured, achieved and improved with time in a systematic manner.

Which means that the lessons learnt in this project can be applied in more future projects with the hope that the gradual constant improvements get us all to the target that we all know we need to achieve, but not sure how to do that (Business and economy helping environment instead of destroying environment and rest of the world).

Protecting the environment is a given in all projects of this system, balancing that with a stable system is the goal.

2- Freedom:
Freedoms of the members who are part of the MEC are a natural result of a self sufficient system.
The current situation in the world proves with no doubts that most systems around the world are more fragile than we thought.

But if you have a self sufficient system (a system that produces its own food, energy, transportation and more), than people can depend on it when things goes in the wrong direction, it's another backup if everything failed.

And of course to be able to reach these goals while balancing everything, we need a good ERP system to help facilitate all the goals at the same time.

2 BACKGROUND STORY: AN ECOCITY

A Multi EcoCity (MEC) is a bigger version of an EcoCity.

2.1 So What is an EcoCity?

"An EcoCity is essentially seen as a community that has high ecological quality, but at the same time it is technologically advanced." (Tuominen, et al., 2015)

So in other words, an EcoCity is a community that improves environment while in the same time use advanced technologies to achieve its goals.

1- Accommodation

One of the biggest parts of an EcoCity – and any city – is its accommodations; there are a lot of different new building technologies that depend on natural materials that doesn't harm the environment, building styles will concentrate on saving energy, using natural building materials and sustainably.

2- Energy

Producing most or all of its energy needs from renewable resources, solar power, wind power and others resources.

This energy will power activities in the city, as well as become a source of direct income (selling direct electricity) and indirect income (selling services that can use this renewable energy).

3- Food

Producing our own food, organic, using natural methods, no chemicals, natural methods are used to produce high quality healthy produce, while maintaining the health of the soil and the rest of the area.

Part of this food can also be sold for a premium, creating an extra source of income.

4- Transportation

Electric vehicles are the way, bike lanes, pedestrians-only areas, car polling and public transportation are all a part of the transportation solutions that will be offered.

Transportation can play a bigger role in increasing the value of all the other services,

For example: if the city was built in a place relatively harder to reach (which means cheaper land prices), creating an electric bus free transporting service to the area can increase visitors numbers and making it easier for people to become residents in the newly created city.

5- Services and Entertainment

Education, medical services, commercial areas and a lot of other services will be available, using the same natural, organic food and renewable energy.

A commercial area that contains farmers market can become an attraction, combining that with free transportation service can create an added value to the whole project (by creating an influx of visitors and customers).

6- Recycling and waste to energy

"Waste generation and treatment in communities is a large and pressing problem, as is energy security. Both can be helped with increasing the use of waste to-energy solutions." (Tuominen, et al., 2015)

One of the most important goals of EcoCities is reducing their carbon foot print, recycling and converting waste to energy is 2 of the most important tools to reach this goal.

There are several technologies that solve this problem with different degrees of success; our goal is to reach the highest degree in success in this particular issue.

7- Big cities vs smaller communities

Let's differentiate here between EcoCity as a concept that governments are trying to apply to big cities, and EcoCity as a self sufficient smaller community built by private sector.

The smaller Self sufficient EcoCity built by private sector is what we are talking about here.

2.2 The trap of EcoCity as a business

Before we talk further about the EcoCity, we need to make sure to avoid the trap of turning a project that is originally designed to help the environment to yet another opportunity for businesses to sell stuff under the "Green" banner

1- Big investments mean big investors?

"The construction of the eco-city project, in fact, may be very expensive due to the green technology requires high initial investment costs." (Joss, Cowley, & Tomozeiu, 2013)

"However, some major projects, closely linked to major public-sector initiatives, have fallen into the hands of private companies that have turned them into an important opportunity for profit" (The Three Pitfalls of Sustainable City: A Conceptual Framework for Evaluating the Theory-Practice Gap, 2017)

For that particular reason, starting this kind of projects is a challenge on that front: How can you build that kind of projects without falling in the hands of big investors?

2- Crowd funding equity: a democratic solution

The internet offers us a lot of opportunities and has changed a lot of things; one main thing is how we fund ideas and projects:
In the last few years, crowd funding have been evolving from donating money to good ideas into a full scale solution to fund ideas by non-investors types.
Individuals with really small amounts of money, when they come together, can cause a huge effect (that is the "crowd" part of crowd funding).
That option - if used in the right way - will give the people back the democratic power to help this project to go in the right direction, to become the model where other similar projects will try to copy (and improve).

2.3 A forgotten important resource for Ecocities:

One of the main goals of an EcoCity is to become as self sufficient as possible.

To produces its own energy, food, water, transportation and other services, basically to have all needed resources available for its residents.

Most people concentrate on these solutions to become self sufficient in most resources, but in the process, they forget a very important resource: Funds.

Estimations about the percentage of failed EcoCities differ, but most experts estimates that around 90% fail (Ecovillages are Restoring Ecosystems Around The World, 2020) , which is similar to failure percentage of startups (90% Of Startups Fail: Here's What You Need To Know About The 10%, 2015)

An Ecocity is a startup, even if the goals are a little different than profits, in the end of the day it is a startup, and need to be dealt with as a startup business.

Because if you did not, it doesn't matter how sustainable you are in every other thing, if your EcoCity can't pay its bills, it will die – sooner or later.

In other words: financial health is crucial for an EcoCity with a long term planning to ensure its survival and growth.

There is a real need to balance finances and economy with the sustainability goals of an Ecocity, somehow to stay true for its purpose without turning to profits first- and everything second - kind of projects, we need to do that to make sure it survive and thrive for a long time to come.

2.4 MultiEcoCity vs EcoCity

While the term "EcoCity" is usually used for one area in one country / region, the MultiEcoCity takes that concept and merge it with Multinational companies to get a new hybrid: An EcoCity that has the ability to become self sufficient and sustainable in its Finances by using a lot of same proven and successful Multinational business rules and practices.

If the MEC was able to prove to the world that it is a successful and profitable example - just like the Tesla cars example - whole industries will follow the lead, creating a new direction in which businesses around the world actually work to improve environment instead of destroying it.

Some of the extra features that the MEC has are:

1- Circular Economy:

"*The circular economy is a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the life cycle of products is extended.*"
(Circular economy: definition, importance and benefits, 2018)

Circular Economy for the economic world is the equivalent of recycling in the physical world: you use outputs of one part as inputs in the next part and NO waste is allowed.

In this model the sum of all parts is more than the parts on their own, with no "waste".

Subprojects from several different sectors in different locations in different countries will create diversified income streams and a more stable system that has a lot higher profits than normal business systems.
For example:

- Tourism
- Retail
- Real estate
- Constructions
- Transportation (electric)
- Energy production
- Food production
- Education
- Information technology services
  And other services

The higher profits can offset the extra costs that we will face because of the environmental guidelines that will be used in MEC model.

An important part of this model is: The MEC will be owned by its residents, each resident will be an MEC owner/ shareholder: Democracy at its best.

2- Why Multi locations and multi sectors?

There will be locations in other cities and other countries to make sure the stability of the whole system, to ensure that it will be always working even when economic or political problems happen in one or more subprojects.

Multi sectors are also to create a stable system despite the different economic cycles for different sectors.

2.5 The curious case of Tesla cars

To understand more what we mean by financial self sufficiency and financial sustainably, let's examine the Tesla cars example:

For a long time, everyone knew that electric cars are better for the world than other kinds of cars, while transportation in general is one of the main contributors for destroying the environment, the automakers industry didn't – or wasn't able – to solve the problem of electric cars:

The problem of egg and chicken: Which comes first: Investments or demand?

They need to invest a lot of money to solve technological problems, but they can't invest a lot of money and time in solving these problems without having a sufficient demand, but the sufficient demand will never come unless they solved these technological problems first.

Then came Elon Musk:
He is a successful business man and a successful programmer / scientist, he started PayPal Company, a company that changed the face of internet in general and one of the main reasons we have the explosion of ecommerce in the world today, so he knows both the technological challenges and financial challenges that comes with new projects with new technologies. (Tesla, 2020)

Before Tesla cars:
In 2010 sales of electric cars were almost nothing.
(7.2 Million Electric Cars Hit the Roads in 2019, 2020)

Consumers did not want electric cars because:
- Electric cars were expensive,
- Not practical
- A lot of trouble compared to petrol vehicles

Automakers did not want to make electric cars because:

- No demand
- Big financial risks for example: General Motors lost 1 billion dollars in General Motors EV1 (GM Pulls Plug On Electric Car, 2003)

After Tesla cars:

In 2019: Sales of electric cars are 2.2 million per year, and there are over 7.2 million cars worldwide. (7.2 Million Electric Cars Hit the Roads in 2019, 2020)

Consumers loved electric cars after Tesla because:

- Electric cars became affordable
- Very advanced
- Higher safety measures
- Practical (charging stations everywhere, less maintenance...etc)

Automakers now love electric cars because:

- High demand
- High profits
- High future growth

Conclusions

A single Company can change the course of an entire industry, if it understood the language of businesses: Demand and profits, while in the same time help to save the environment.

To create market changing demand: you create what consumers want by solving their problems in new ways, giving them solutions they did not see anywhere else, and make sure it becomes really famous and viral.

Business sector sees demand and translates it to profits; business does what it does best: Supply the demand, if supplying this particular demand saves the world, our mission is done.

2.6 Can one project create a change big enough?

The end goal of the MEC is to create a change on the biggest scale possible, using business practices and environmental guidelines to solve one of the biggest problems in one of the biggest sectors in the world: Constructions sector.

Just like Tesla cars was able to stimulate worldwide change in automakers industry by understanding the programming language of profits, MEC can do the same for construction sector, creating a worldwide change that might one day help in saving the environment.

2.7 MEC and ERP

Because MEC is more like a multinational corporation with multidimensional businesses in different economic sectors, we need a good system to connect everything together, to ensure everything is working smoothly, a system that can grow and adapt to our needs, give us freedom to solve our problems in new innovative ways without costing too much and becoming controlled by another business company (ERP system provider company for example), hence building our own customized ERP system is the logical solution.

3 DEFINITION BACKGROUND AND OPERATIONAL ENVIRONMENT

3.1 Definition background:

This is a project to build a flexible and customizable ERP system that can adapt to the needs of the MultiEcoCity and has the following characteristics:

1- Cost effective:

Most ERP systems in the world right now are a very high investment in money, in hundreds of thousands or even millions of dollars.

In our project, we need a cost effective way to solve the ERP need without investing so much capital in it, and at the same time without sacrificing quality.

2- Easily Customized:

Sometimes you need to customize certain aspects to an ERP system, a lot of ERP systems providers don't give you that option at all, or make it very hard and expensive to use that right.

Building your own system means you can customize it as much as you need, with less constrains (other than time, costs and technical constrains)

3- Gives you control:

A lot of ERP systems - especially the lower priced ones - takes away a lot of control from the users, but if you built your own ERP system, then you can get back that control on technical aspects of the project as well as business aspects or any other aspects.

4- Easily maintained:

Programming languages are a living organism, you need to keep it updated and well maintained.

Choosing a programming language that has a wide base of users translates to a wide base of developers and a faster cycle of updated software.

3.2 Background and operational environment

1- Cloud based project

This project will live on the cloud because of its accessibility and cost effectiveness.
Being on the cloud means more options regarding backup, restore and more.
Also it means worldwide accessibility for users, employees and everyone in between.

2- PHP language

The computer language that is needed to handle such a project needs to have the following characteristics:

- Have a broad base of programmers and users to keep it well maintained, updated and secured
- Have been around for a while, to have enough numbers of programmers available.
- Have many projects that are similar to ERP systems (to be able to learn from their mistakes and know what works and what doesn't work)

In my opinion, PHP language is a good candidate for this project for the following reasons:

- PHP is a general-purpose scripting language that is especially suited to web development.
- It has a broad base of users and programmers (78% of website in the world is built using php, that is 8 out of each 10 websites worldwide! (Usage statistics of PHP for websites, 2020)
- It has a lot of tools built around it,
- It has a lot of programmers ready to jump in,

So that will make it easier to build our ERP system especially for the following reasons:

- There are already solutions that can solve most of the ERP problems with minimal customizations.
- Building extra packages will not be expensive or hard since already a lot of programmers are available to do that.
- Maintaining the software will not be a problem for the same reason.
- A lot of solutions will be built on already available solutions that have an active base of users, which will ensure timely updating and upgrading, and constant fixing of any security problems that might arise.

3.3 Current situation and ERP systems

There is no room for small companies to use ERP systems, as it cost goes in hundreds of thousands of dollars to have a fully operational ERP system in a typical company.
(How Much Does an ERP System Cost?, 2020) (How much does ERP cost?, 2019)

3.4 MEC Project needs analysis

The MEC will be worldwide project, with less capital than project of its same size.
It will deal with same commercial / business needs that normal companies will face, but also will have its own challenges, to try to be environmental from the ground up, and to work for the long term plans of becoming self sufficient on several fronts.

That means it needs a lot of in-house talents, as well as opens source affordable solutions.

To counter attack all that, there will be diversification, and the project will try to use its multinational position in working in several sectors in several countries, which will give it more stability and better position than most other projects.

Being a relatively small organization can also be a success factor instead of being a problem, by adapting to problems and find solutions faster than bigger organizations.

We will concentrate here on the part of this project that will deal with online sales of products and services, inventory system and its connections to the purchasing system, CRM system, contacts system and HR system.

The ERP system that is needed have to have the following modules, all connected to each other and all have the ability to connect to other outside modules or systems:

- Accounting module: basic expenses, costs and profits (will connect later to the external main accounting software that will take care of all accounting and taxes needs in a more official way).

  We need an accounting module because most of the available accounting software packages are either very expensive or very limited in customizations options, using our own module; we can customize how people and other systems will interact with the accounting part, before we send the information to a more advanced external accounting system.

- Sales module: Online sales operations
- Inventory module: Products, inventory management ...etc
- Purchasing module: Purchasing products and services
- CRM module: Customers relationship management
- Contacts module: All companies, purchasing companies, people we interact with ...etc
- HR: Human resources module

The rest of the modules will be the same principles.

4 DEVELOPMENT TASK AND OBJECTIVES

4.1 Needed modules in the ERP

There are number of modules that will be need in this project, but for the case of simplicity, we will concentrate on the following modules that will be used mainly with ecommerce website:

1- Online sales:

This module handles products, orders, payments and all other aspects for an online sales portal.

It also connects to accounting and inventory systems to make sure they are always updated with the needed information.

2- Inventory management:

This module handles inventory, orders fulfillment, buying needed products, expiration dates, products costs and more.

It also handles shipping products to warehouse and to customers, as well as returns.

3- CRM:

This Customers Relationship Management module handles information about customers, their orders, support and more.

It also has information about other parties we deal with, like suppliers, service providers and more.

4- Accounting:

This module handles payments, costs, expenses, profits, and most accounting needs for a simple online portal, as accounting is more complex than one module, this module will pass the information to a more advanced accounting system that works on its own in the background.

The other external accounting system will also collect more financial data from other sources like banks, online payment processors and more.

5- Human resources:

This module will handle employees' information, holidays and more.
This module also connects with accounting module to get the data about salaries and other employees' financial data.

There will be more modules that will use the same concepts.

4.2 ERP system entities:

ERP is the ecosystem that contains all different modules, it deals with different parts of information inside an organization, it is consists of entities, and each family of entities has certain properties, following are example of some of these entities:

Table 1: ERP entites

Entity abbr.	Name	Comments
PO	Purchase Order	To add more inventory to the warehouse
SHO	Shop Order	Ordered by customers in an ecommerce site /shop
LOT	LOT	A batch of products purchased together
INO	Inventory Order	A batch of inventory ordered / sold together
PRD	Product	A product as an entity
USR	User	A system user
COM	Company	Company / organization / service provider
DOC	Document	Documents / receipts...etc
PER	Person	People / Contacts …etc
EXP	Expense	Expenses
SRV	Service	Services

4.3 Relationships between entities

These entities are organized in families/groups, and the interaction between each entity and the other entities is what ERP is all about.

These interactions are governed by their properties, rules, and permissions that users and other entities have.

4.4 Permissions

Who, when and how to change relations between entities, or changing their values and / or properties of entities, this all is controlled by permissions , users, roles, dates, kind of entity ...etc.

4.5 OOP Object oriented programming similarities

Entities, relations, properties and permissions are all the reason we have Object Oriented Programming, it is part of the whole system, and in the middle of all this comes CMS that evolved to a lot more, we can use OOP to manage and control the entities, and creating the ERP system that can be customized and managed in a way a lot of easier and more cost effective than what we have today, just need to combine number of different system under one ecosystem.

In the following chapters I will explain how to do that, using these readily available systems, how to make them work together and speak to each other, all under one ecosystem to make things easier to manage.

5 RESEARCH METHOD: ACTION RESEARCH

5.1 What is Action Research?

Action research is a philosophy and methodology of research that is designed to diagnose problems or weaknesses - whether organizational, academic, or instructional - and help researchers develop practical solutions to address them quickly and efficiently using the following steps:

(Bryman, 2011)

(Collis, 2003)

1- Plan:

Planning in order to initiate change, or in other words: to choose the needed steps to reach the planned goals.

We need to write down exact goals, goals that can be measured, to know exactly what is needed to be done and when it is done.

2- Act:

Implementing the change (acting), here we actually do the steps to reach each goal / result.

For example: We collect, process data, we implement modules, we test interactions between different parts of the system…etc

3- Observe:

Observing the process of implementation and consequences, we observe the actions we did in the first stage and the results to see what happened, how it is happening and more.

It helps us to answer next questions like for example:

Did our planning to reach these goals and taking the steps to these goals give us the end results we need or not?

4- Reflect:

After observation stage – which is data collecting stage - we go to the next stage; to reflect:

We reflect on processes of change and re-planning:

We reflect if the goals that we reached are enough or not.

We ask questions like:

What can be improved?

What kind of problems we need to solve or avoid?

5.2 Why action research?

Because this is both a programming problem and business problem at that same time, they go in these cycles naturally, with each cycle you improve your solution and reflect on what you did so far, find more problems to solve, new steps to take, new goals to reach, until reaching the final bigger goal.

1- Action research, organizational development and cycles

There is strong connection between methods used in Organizational development, social sciences for change and the action research method.

For example: Wendell L. French and Cecil Bell talked about the connection between them by calling the process "organization improvement through action research" (French & Bell, 1973)

In describing steps needed for permanent change, Lewin described steps needed as following: "proceeds in a spiral of steps, each of which is composed of a circle of planning, action and fact-finding about the result of action" (Lewin, 1958)

6 SYSTEM COMPONENTS

6.1 Components

- We need to choose the components of this ERP system.
- Add components together.
- Test their connections.
- Find the missing entities / connections.

The following components are needed:

1- The Main Ecosystem: Wordpress

The Ecosystem, where all the other parts will live, we will use Wordpress.

It is surprising to many that a CMS like Wordpress can be used to something like this, but it is the most popular CMS in the world today (builtwith.com, 2020) with millions of website, that means a lot of packages / modules are already available for it, and it is always under test by 10s of millions of users worldwide.

2- Woocommerce

Is the most popular ecommerce plug-in for Wordpress, with more than 3 million Ecommerce website worldwide (builtwith.com, 2020) , so it is a good starting point for entities like products and online sales operations.

3- Post Types creator (entities creator / manager)

There will be new post types, and some post types will be extended to change its characters' as needed.

4- Advanced Fields creator (properties creator / manager)

To create text fields, number fields, images fields, check boxes fields, dates fields, and more

5- Permissions creator / manager

Users will have roles, and each role will have its own permissions for each post type, field and form, to make sure that the right person has the right permissions to what they are doing.

6- Forms / interface / I/O

- Where all the input will happen,
- The results /output will be shown depending on your user permissions

7- Backend / forms creator

Using a form builder that can connect post types, custom fields and more together

8- Security standards:

Firewall / Antivirus / Backup …etc
Version / serial number system

7 CYCLE 1: INVENTORY MANAGEMENT MODULE

7.1 Goals of inventory management module:

Creating an inventory module (inventory management system) that can track goods and orders throughout the entire supply chain, from purchasing to warehousing to end sales.

7.2 PLAN

We start by planning to fulfill the following needs for this cycle:

1- Sales order fulfillment

Our sales system will get sales orders, we need to fulfill them in an efficient and timely manner that means we process payments, confirm order with client, confirm order with warehouse, make sure that the order have been shipped in the correct time frame, and that the client got their order in timely manner.

2- Inventory Tracking:

Knowing where any piece of inventory is in the supply chain at any given time.
Make sure to order new inventory in the correct time, to make sure to have enough inventory, not too much, not too little, to be able to fulfill orders coming from sales channels.

3- Inventory transfer Management (between warehouses)

Managing inventory movements between locations with ease.
Make sure to put pieces of inventory in the best locations possible to minimize time and costs for fulfilling orders.

4- Purchasing Management

Managing products orders coming from warehouse.
Manage relations with different suppliers.

5- Shipping Management

Make sure that shipping processes, shipping companies are all working together in an efficient way.

Manage shipping products from supplier to warehouse.

Manage shipping products to customers.

Manage products returns.

6- Reporting and Analytics

Collect information from different parts and showing them in a useful manner for easier decision making.

Create reports that can summaries important key information in the whole system.

Now, in Woocommerce, you can add products, accept orders, and have some control on shipping, but there is no real inventory management, warehousing, transfer, purchasing management, costs, expenses and a lot of other parts that we will add in the coming parts

So the following entities in table 2 will be used

Entity abbr.	Name	Comments
PO	Purchase Order	Order used to buy inventory to the warehouse
SHO	Shop Order	Sales orders by customers in an ecommerce site /shop
LOT	LOT	A batch of similar products purchased together
INO	Inventory Order	Ordering inventory from the warehouse
PRD	Product	A product as an entity
USR	User	A computer system user (website, ERP system…etc)
COM	Company	Company / organization / service provider
DOC	Document	Documents / receipts...etc
PER	Person	People / Contacts …etc
EXP	Expense	Expenses at the warehouse / shipping
SRV	Service	Services at the warehouse / shipping

Table 2: Inventory module entities

7- How the logic goes?

1- Shop order comes from Ecommerce shop (a sale was made)
2- Inventory order is issued for every product in each shop order (INV connected to SHO) to warehouse management
3- Inventory manager check inventory orders, see what can be fulfilled from inventory, what can be fulfilled directly from other suppliers to consumer, and what needed to be brought to warehouse first (if any).
4- Inventory manager send draft purchase order with items needed in warehouse to purchase manager.
5- Purchase manager choose suppliers and confirms purchase order.
6- PO is tracked until products reaches warehouse.
7- Once products reach the warehouse, it is grouped in LOTs
8- INV that has not been fulfilled yet is than fulfilled using LOTs

9- All shipped orders and purchasing orders are tracked using shipping module.

7.3 ACT

1- Installing needed packages / plugins

To get the needed functions, we need to install number of different plugins, after testing compatibilities and functions; the following plugins are working smoothly together.

The extra functions needed will be fulfilled using custom made codes in some of the modules.

Table 3: Plugins names - inventory module

Plugins Name	Plugins role (job)
Custom Post type	Creating / extending entities and fields / properties
Advanced Custom field	Creating fields / properties
Permissions manager	To manage users permissions
Pages builder	To build views
Forms builder	To build interfaces that end user can use to create, update or delete data

2- Creating entities

Using Custom post type, entities where created:

Using the entities tables, we know how many entities to create.

Inside entities we have fields that can connect entities to each other.
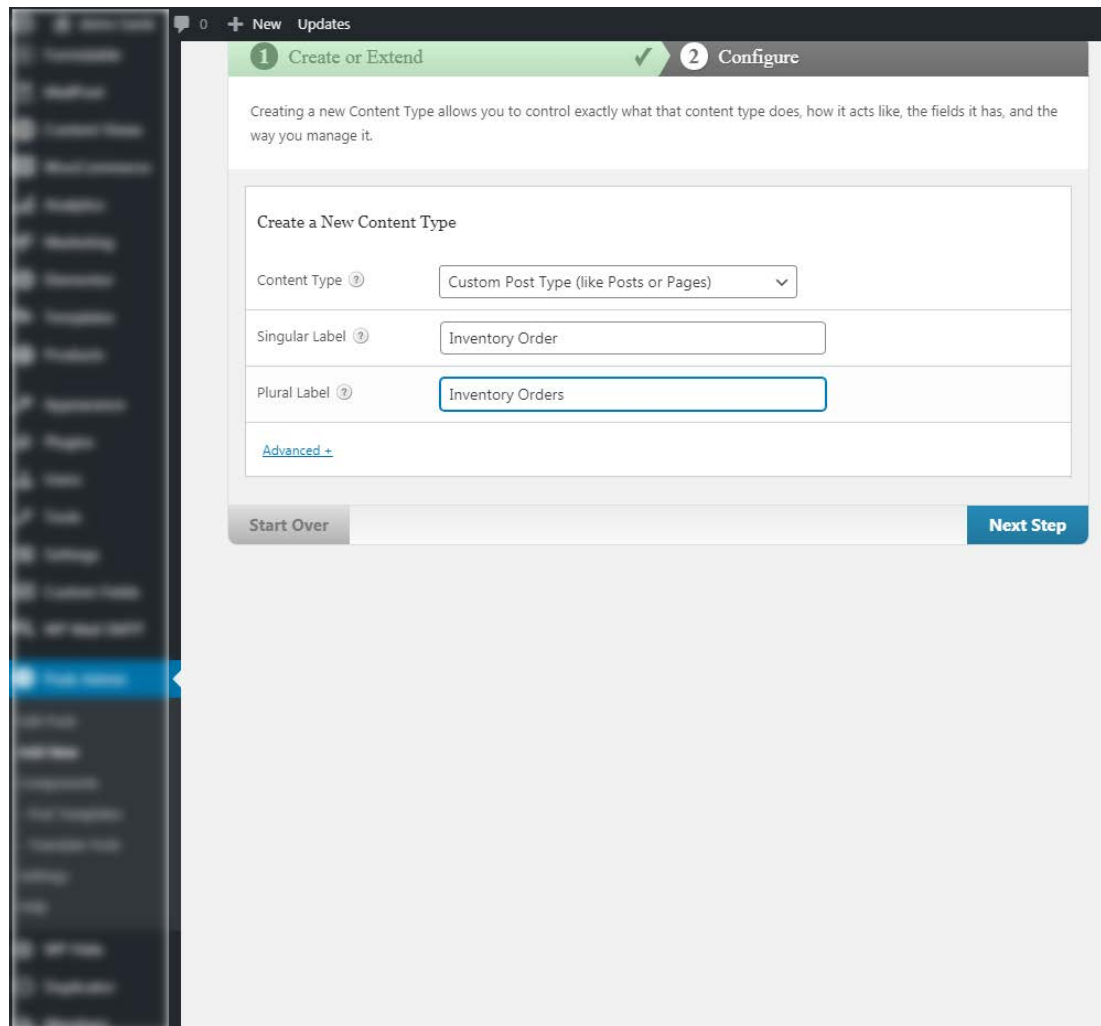
Every different entity is created as a custom post type, this happens in the backend. After we create entities that we can choose permissions of who can create or manipulate any aspect of it

Example for creating an entity:

Following is an example where we create an entity as a post type, in this example it is an Inventory order (INV), inside which we will create fields, connect it with other entities using relationships.

Screenshot of creating an entity / post type

Figure 1: Creating entites (inventory order)

After we created number of entities for this module, now we have entities list for the Inventory module:

We can see number of entities in this list, which you can check in table 2: Inventory modules entities list

List of entities after creating them:

Label	Name	Type	Storage Type	Number of Fields
COMs	com	Custom Post Type	Meta	0
DOCs	doc	Custom Post Type	Meta	0
EXPs	exp	Custom Post Type	Meta	0
INOs	ino	Custom Post Type	Meta	0
LOTs	lot	Custom Post Type	Meta	0
PERs	per	Custom Post Type	Meta	0
POs	po	Custom Post Type	Meta	0
Product	product	Post Type (extended)	Meta	0
Shop Order	shop_order	Post Type (extended)	Meta	1
SRVs	srv	Custom Post Type	Meta	0
User	user	User (extended)	Meta	0
Label	Name	Type	Storage Type	Number of Fields

Figure 2: list of entities

3- Creating fields inside entities

After creating each entity, we need to create fields inside these entities; fields are containers of different kinds of data, some of these fields are connectors to other entities (relationship fields).

Fields are created inside each Custom post type, each field is a property, could be text, date, numeric, select…etc

One of the most important fields to create is serial numbers, it is a unique field, can be created once, and it is important for the auditing trail for the whole system

How to create a property (field):

There are number of different kinds of fields, we can create text, numbers, emails, relationship fields, even connect directly to table data in the database using different fields.

We can see that we can create a field; we need to fill the following information:

Field label (for internal use between different entities), field Name (which end users can see), field type (which dictates what kind of data will be put in this field), required field or not.

Figure 3: Creating a property / field

Example: PO fields / properties table:

Property (field) name	Property type	Comments
PO serial number	Number	Unique serial number
PO status	Relationship / taxonomy	PO draft / Sent to vendor / Waiting for Vendor / Vendor sent product / Delivered …etc
PO notes	Relationship	Connected to DOC post type (Document note)
Supplier	Relationship	Connected to COM post type (supplier company)
Products	Relationship	Connected to products
SRV	Service	Services at the warehouse / shipping

4- Connect entities together

There is special kind of fields that is called Relationship field that is used to connect entities together.

For example: One SHO (shop order) can have several PRO (products) connected to it, several PO connected to it…etc as we can see in the following example:

Example for entities relationships:

Connect INO to SHO:

Processing a shop order (SHO) by adding (connecting) inventory orders (INOs) for each product

Example of how we can create this relationship field in the first place as following:

Creating a relationship field between 2 entities (Inventory order to Shop order, INO to SHO

Figure 5: Creating relationship between entities

Bi-directional field means that if changes have to show up in both ends of this relationship (if you change this field in INO it shows in SHO and vice versa)

5- Creating permissions

After we create different entities and fields, we need to answer a more important question:

Who has the right to create/update/delete what field or entity?

For that question, we create a table of permissions to know which user role has the permission to do what.

Example: Following table shows example of permissions, which user role can create what:

Table 4: Permisions and user roles

User role	Comments
Purchase manager	Confirm PO / Issue PO
Shop manager	Manage sales orders by customers in an ecommerce site /shop
Inventory manager	Issue PO draft only / create INO to fulfill SHO

6- Create interface / forms (interact with data)

All the fields have a back end, but to be able to control who can do what, we need to create forms, which is the front end interfaces that are needed to be used by different users to fulfill different tasks from them.

Example Creating forms:

Screenshot of backend of a form creator

Figure 6: Creating forms backend

After creating a form, we connect it to its special entity (custom post type) so it can handle the data input, perform any necessary needed tasks (verifying these data for example, making sure it is the correct kind of data …etc) before it can become an input to the entity.

Example connecting form to custom post type:

Screenshot of backend of a form creator to connect the form with custom post type and custom fields.

Figure 7: Connect form to custom post type

7.4 Observe

1- Up until now:

We did the following:
- ERP entities that user can create, update and delete according to permissions
- Fields / properties for these entities
- Connections / relationships between entities and each other and between different fields.

2- Next steps

1. Communicate with systems outside the module (especially the accounting software)
2. Improve the security of the whole system
3. Improve the Audit trail of the system
4. Add more advanced features for the accounting parts of this module
5. Create more modules

8 RELIABILITY AND VALIDITY

To check the reliability and validity of this system, we need to ask ourselves the following questions:

1- Can the results of this system be repeated?
2- Can we depend on this system in real life situations?
3- Can this system be copied and used by other users / companies?

8.1 Can the results of this test be repeated?

Most components of this system are open source and readily available in the Wordpress ecosystem, the ERP system used most parts to do things they are already doing, so the results of this test can easily be repeated.

8.2 Can this system work in real life situations?

To answer this question, this system was used with a working e-commerce website to test if it works or not.

The company was a mini-multinational company that works between China, Germany and the Middle East.

The inventory module improved the inventory management, made it easier and faster, lowered costs compared to using an external inventory system.

The simple accounting part (adding costs of services performed in the warehouse) helped in managing extra expenses for warehouse services. (Any services that are performed on top of drop shipping, for example re-packaging…etc)

The simple accounting module helped also in controlling the e-commerce module and to see a better view for profits when taking different decisions.

Unfortunately, doing deeper analysis on the profits and losses …etc will need external accounting software to do most of the advanced tasks because the kind of expertise these accounting companies have, and because the scope of building an entire accounting module is bigger than we planned, but still the cooperation of both the simple accounting module and the external accounting software proved to be very helpful.

8.3 Can this system be copied and used by other users/ companies?

Deploying this system is both easier and harder for other companies.

Easier because it is less complicated than other ERP systems, which makes it easier to be learned.

Harder to deploy because it is a custom made system, so it doesn't have a lot of external consultants that worked with it before.

However, because most modules are built on already available technologies, so there are consultants who worked with these technologies (plugins and software), they will take less time to learn how the whole system work together.

9 CONCLUSIONS

9.1 What did we conclude from planning and building that system?

Main conclusions:

- Building an ERP system using free open source available software packages is possible.
- We need to map all entities, relationships, permissions, logic and steps before we start building the system.
- Combining this system with more advanced external systems can go a long way of reaching the goals using the most efficient ways (example: Accounting module connected to a more advanced external accounting software)

Let's examine the system advantages and disadvantages:

9.2 System Advantages:

- Price: Most components of this system is either free or much cheaper than usual ERP systems
- Customizable: You can add, delete, change, redesign or otherwise customize this system anyway you like without paying huge amounts of money to the company that own the ERP system because you are the owner and designer.
- Dependable: Since it is built on other systems that have been in the market for a long time, has a big customer base and big programming companies behind them, they are usually dependable and always being developed, updated …etc

- Availability of programmers: Since this system is built on already existing software packages using one of the most popular CMS systems in the world (builtwith.com, 2020), using one of the most PHP computer languages in the world (Usage statistics of PHP for websites, 2020), than there are more programmers available to help develop and maintain this system.

9.3 System disadvantages:

The biggest "possible" disadvantage for this system is security, so we need to discuss: Is this system secure or not?

- Is this system secure?
  Since this system is built inside the Wordpress ecosystem, there is a possible problem of security (Jackson, 2020) , Wordpress is one of the most used CMS systems in the world (builtwith.com, 2020), it is also a bigger target for hackers (same problem Windows desktop users have), but does this mean it is less secure?

  We need to differentiate here between Wordpress itself and its plugins, According to WPscan website statistics (WPscan Wordpress scanner is one of the most used tools by security professionals for Wordpress penetration testing) only 5% of Wordpress vulnerabilities are from Wordpress itself, while 87% comes from plugins and 8% from themes. (WPscan, 2020)

  Plugins and themes can be built by anyone, which makes them more vulnerable for bad coding practices.

  That being said, because of the popularity of Wordpress, there is a big market for securing Wordpress and solving its security problems, which results in vulnerabilities being discovered and fixed more regularly.

That also mean there are far more security products for this system than other ERP systems, the important point here is to chose wisely, and stay updated on the latest security issues (which is usually true no matter what kind of system you are using)

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TABLES USED

FIGURES USED