In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from scipy import stats
import seaborn as sns
```

Analysis of machine_meta csv -

In [2]:
```
machine_meta = pd.read_csv('data/machine_meta.csv', header=None,
                           names=['machine_id','time_stamp','failure_domain_
                                  'failure_domain_2','cpu_num','mem_size','s
machine_meta.head()
```

Out[2]:

	machine_id	time_stamp	failure_domain_1	failure_domain_2	cpu_num	mem_size	statu
0	m_1	0	219	17.0	96	100	USIN(
1	m_1	148984	219	17.0	96	100	USIN(
2	m_1	535156	219	17.0	96	100	USIN(
3	m_1	552384	219	17.0	96	100	USIN(
4	m_1	658423	219	17.0	96	100	USIN(

Analysis of machine_usage csv -

In [4]:
```
# Reading 50 Million rows
machine_usage = pd.read_csv('data/machine_usage.csv', header=None, nrows=50(
                            names=['machine_id','time_stamp','cpu_util_perce
                                   'mem_util_percent','mem_gps','mkpi','net_
                                   'net_out','disk_io_percent'])

machine_usage = machine_usage.sort_values(by='time_stamp')
machine_usage
```

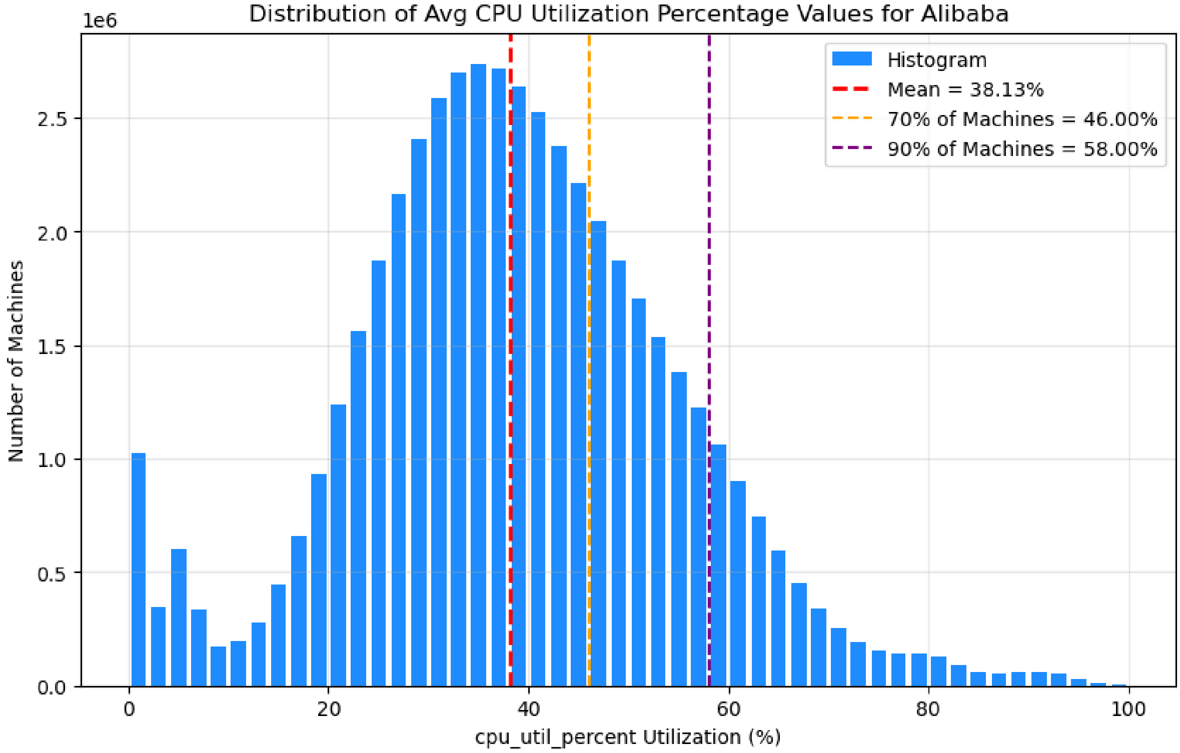
Out[4]:

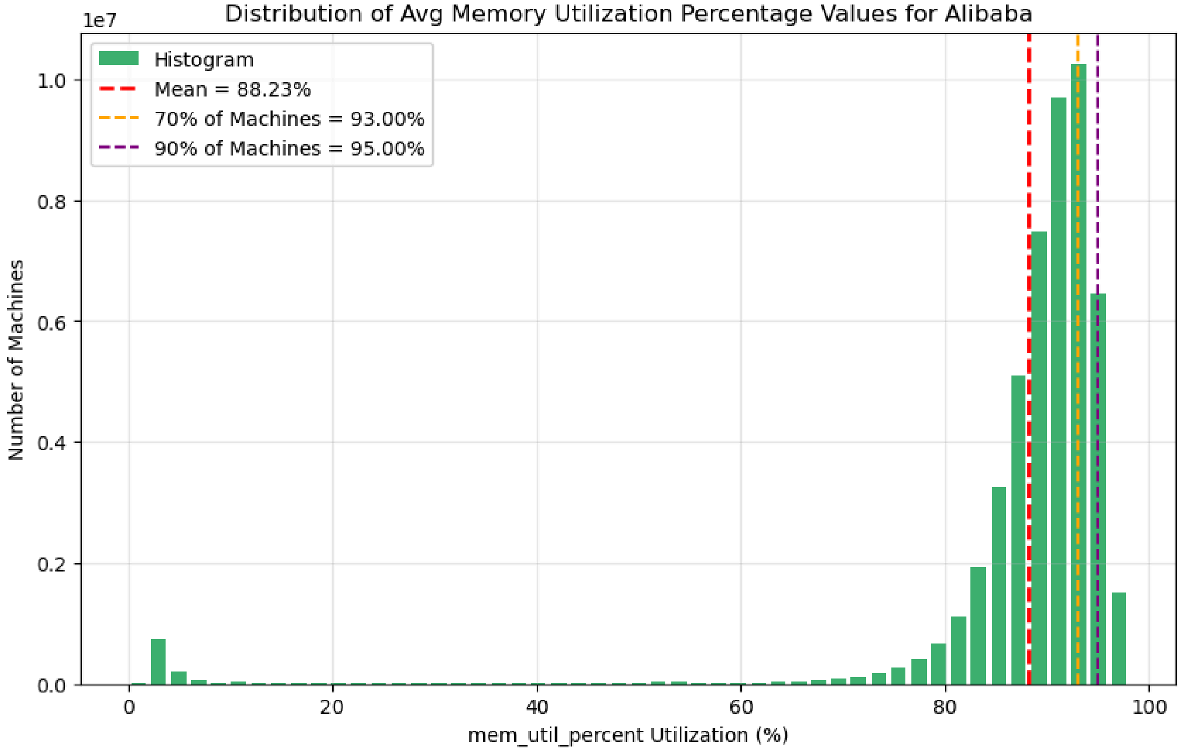
	machine_id	time_stamp	cpu_util_percent	mem_util_percent	mem_gps	mkpi
44625343	m_425	0	47	89	NaN	NaN
18549314	m_626	0	20	90	NaN	NaN
7872991	m_3089	0	7	88	NaN	NaN
42495312	m_111	0	18	92	NaN	NaN
47147418	m_796	0	24	75	NaN	NaN
...	...	...	...	...	...	...
5118577	m_2682	691190	24	96	3.22	0.0
22689894	m_1234	691190	34	93	3.83	0.0
49827147	m_1189	691190	32	94	4.53	0.0
48406478	m_979	691190	85	90	0.41	0.0
48543814	m_999	691190	39	96	15.96	0.0

50000000 rows × 9 columns

In [5]:

```
def plot_resource_analysis(dataframe, col_name, xlabel, title):
    plt.figure(figsize=(10, 6))
    data = dataframe[col_name].dropna()
    mean_val = data.mean()
    p70 = np.percentile(data, 70)
    p90 = np.percentile(data, 90)

    color = "dodgerblue" if col_name.startswith('cpu') else "mediumseagreen'
    plt.hist(data, bins=50, rwidth=0.75, color=color, label='Histogram')
    plt.title(title)
    plt.xlabel(f"{xlabel} Utilization (%)")
    plt.ylabel("Number of Machines")
    plt.axvline(mean_val, color='red', linestyle='--', linewidth=2, label=f
    plt.axvline(p70, color='orange', linestyle='--', linewidth=1.5, label=f
    plt.axvline(p90, color='purple', linestyle='--', linewidth=1.5, label=f
    plt.grid(True, alpha=0.3)
    plt.legend()
    plt.savefig(f'alibaba_{col_name}_distribution.png', dpi=300, bbox_inches
    plt.show()

plot_resource_analysis(machine_usage, 'cpu_util_percent', "cpu_util_percent'
plot_resource_analysis(machine_usage, 'mem_util_percent', "mem_util_percent'
```



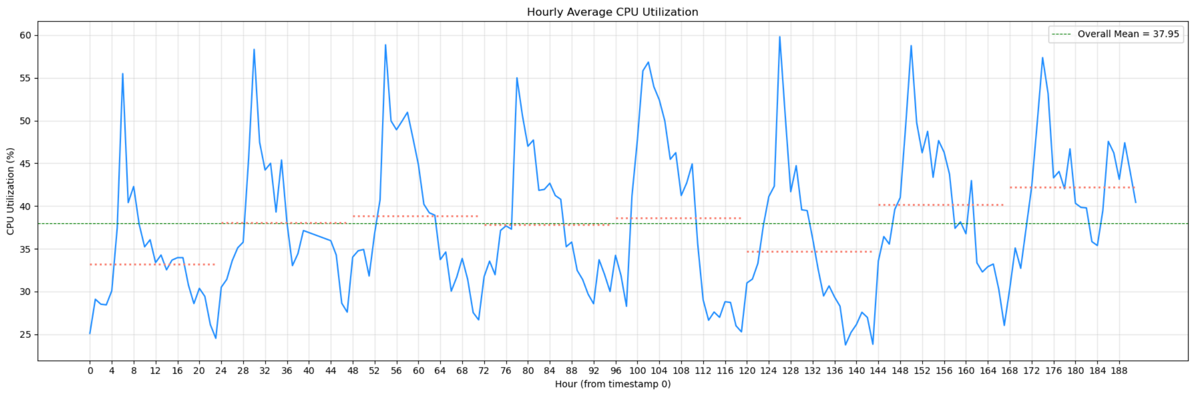


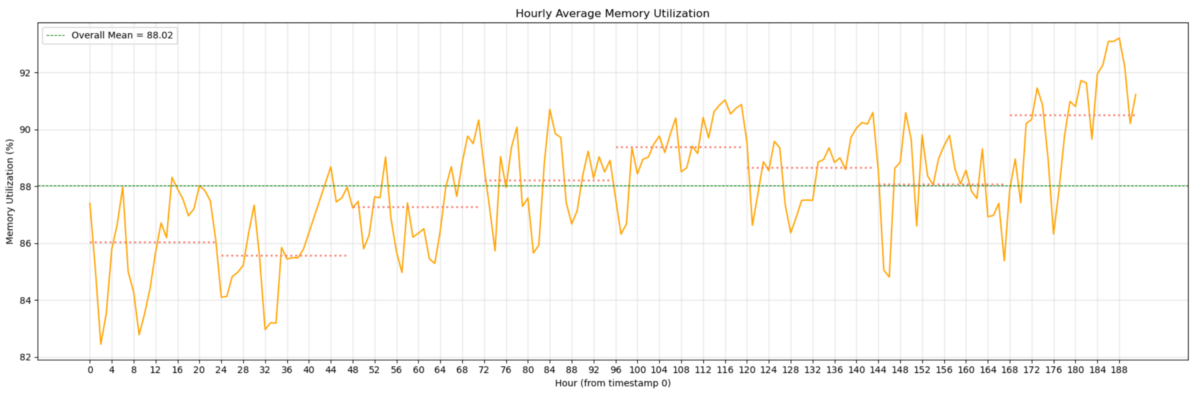
Hourly CPU & MEM Utilization Patterns -

In [6]:

```
# Splitting data into hours
machine_usage['hour'] = machine_usage['time_stamp'] // 3600
# Calculating hourly averages
hourly_avg = machine_usage.groupby('hour')[['cpu_util_percent', 'mem_util_pe

def plot_with_24h_means(data, col_name, color, ylabel, title):
    plt.figure(figsize=(18, 6))
    plt.plot(data['hour'], data[col_name], color=color, linewidth=1.5)
    overall_mean = data[col_name].mean()
    plt.axhline(y=overall_mean, color='green', linestyle='--', linewidth=0.8

    max_hour = data['hour'].max()
```

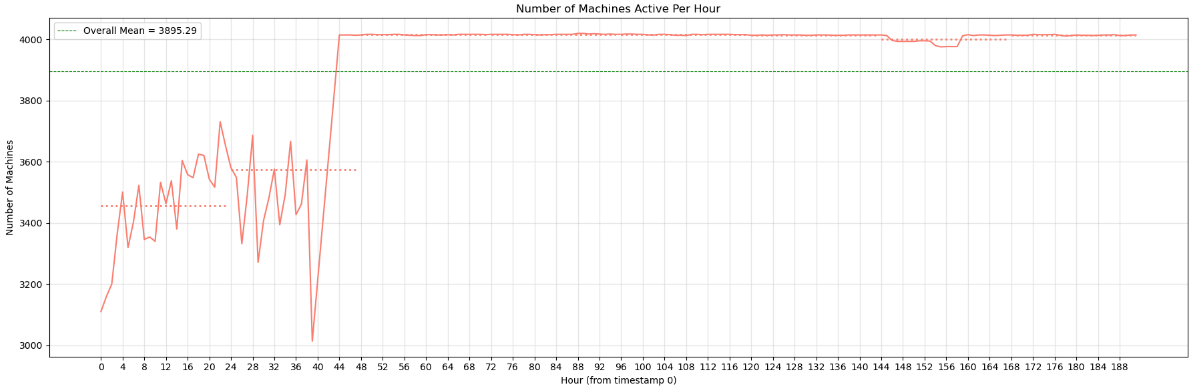
```
    for start in range(0, max_hour + 1, 24):
        end = start + 24
        block = data[(data['hour'] >= start) & (data['hour'] < end)]
        if not block.empty:
            block_mean = block[col_name].mean()
            plt.hlines(y=block_mean, xmin=start, xmax=min(end - 1, max_hour

    plt.title(title)
    plt.xlabel('Hour (from timestamp 0)')
    plt.ylabel(ylabel)
    plt.xticks(ticks=np.arange(0, max_hour + 1, 4))
    plt.grid(True, alpha=0.3)
    plt.legend()
    plt.tight_layout()
    plt.savefig(f'alibaba_plots/Alibaba_{col_name}_plot')
    plt.show()

# Plotting CPU Utilization
plot_with_24h_means(data=hourly_avg, col_name='cpu_util_percent', color='do

# Plotting Memory Utilization
plot_with_24h_means(data=hourly_avg, col_name='mem_util_percent', color='ora
```





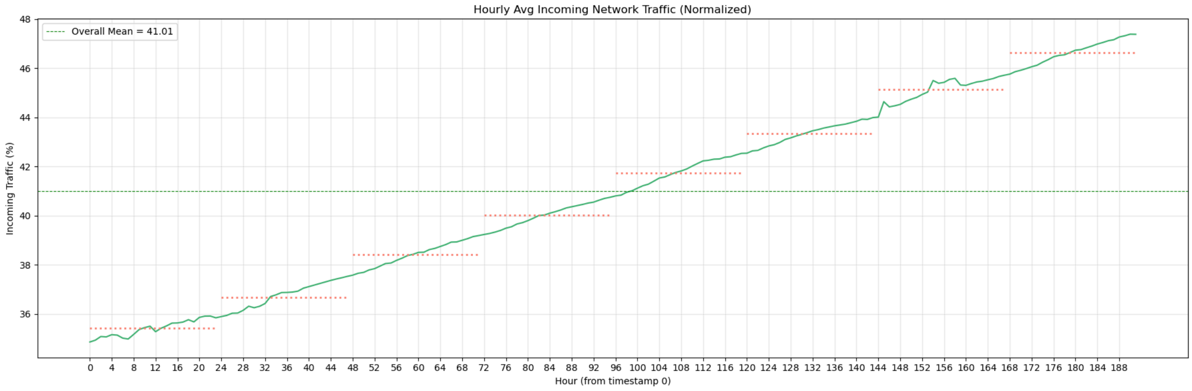
Machine Utilization Patterns -

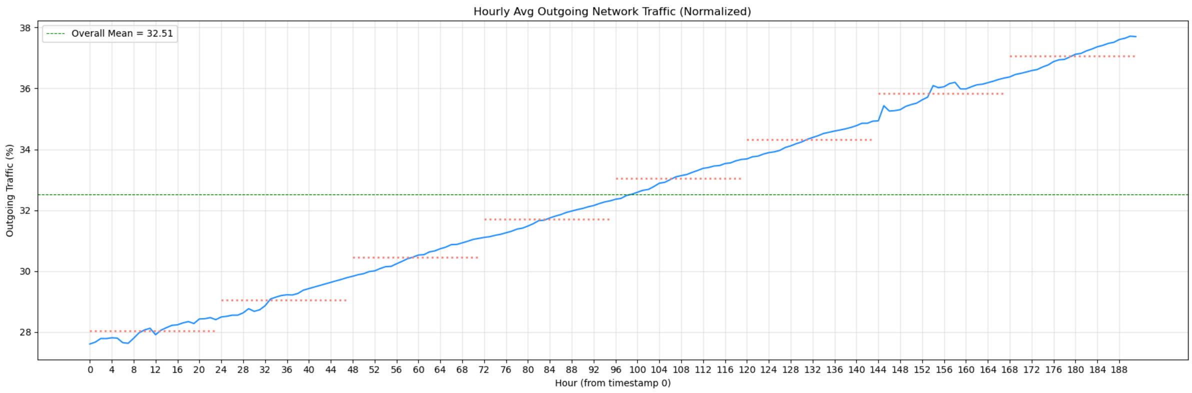
In [7]:
```
machines_per_hour = (machine_usage.groupby('hour')['machine_id'].nunique().
plot_with_24h_means(data=machines_per_hour, col_name='num_unique_machines',
```



Incoming & Outgoing Traffic Patterns -

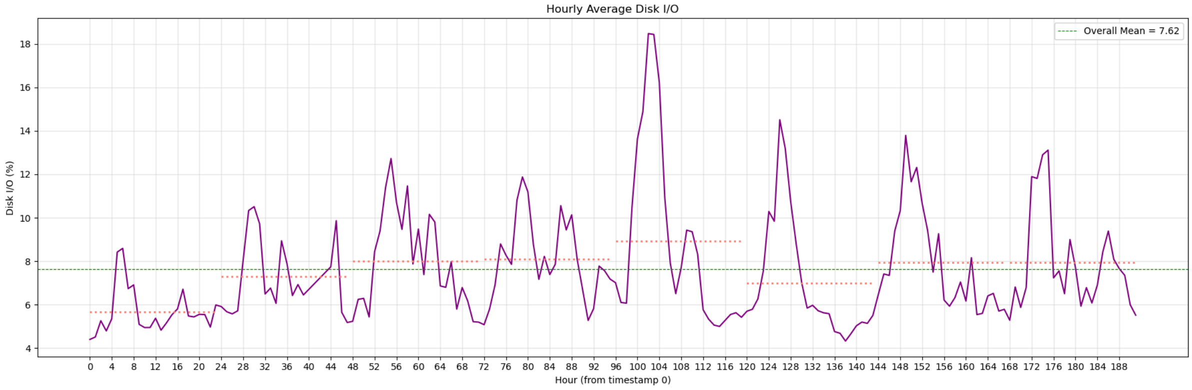
In [8]:
```
hourly_net = machine_usage.groupby('hour')[['net_in', 'net_out']].mean().res
plot_with_24h_means(data=hourly_net, col_name='net_in', color='mediumseagree
plot_with_24h_means(data=hourly_net, col_name='net_out', color='dodgerblue',
```





Disk I/O Percent Patterns -

In [9]:
```
hourly_disk_io = machine_usage[(machine_usage['disk_io_percent'] >= 0) & (ma
hourly_disk_io = hourly_disk_io.groupby('hour')[['disk_io_percent']].mean()

plot_with_24h_means(data=hourly_disk_io, col_name='disk_io_percent', color=
```



Analysis of container_meta csv -

In [10]:
```
container_meta = pd.read_csv('data/container_meta.csv', header=None,
                             names=['container_id','machine_id', 'time_star
                                    'mem_util_percent','cpi','mem_gps','mpl
                                    'disk_io_percent'])
container_meta.head()
```

Out[10]:

	container_id	machine_id	time_stamp	cpu_util_percent	mem_util_percent	cpi	mem_g
0	c_1	m_2556	0	app_5052	started	400	4
1	c_1	m_2556	287942	app_5052	started	400	4
2	c_1	m_2556	338909	app_5052	started	400	4
3	c_2	m_962	0	app_8125	started	800	8
4	c_2	m_962	23205	app_8125	started	800	8

Analysis of batch_task csv -

In [11]:
```
# Reading 50 million rows
batch_task = pd.read_csv('data/batch_task.csv', header=None, nrows=50000000,
                         names=['task_name','instance_num','job_name','task_
                                'status','start_time_task','end_time_task',
batch_task = batch_task[batch_task['status'] == 'Running']
batch_task.head()
```

Out[11]:

	task_name	instance_num	job_name	task_type	status
102	task_MTM0ODUxMTY0NjQzMTI1NTc1MQ==	1.0	j_85	6	Running
103	task_LTE4NjUxMjg5NDY5MDI4NjAzNzU=	1.0	j_85	6	Running
277	task_LTE4NjUxMjg5NDY5MDI4NjAzNzU=	1.0	j_189	6	Running
742	task_LTE4NjUxMjg5NDY5MDI4NjAzNzU=	1.0	j_655	6	Running
743	task_MTM0ODUxMTY0NjQzMTI1NTc1MQ==	1.0	j_655	6	Running

In [12]:
```
running_tasks = batch_task[batch_task['status'] == 'Running']
running_tasks = running_tasks.sort_values(by=['start_time_task', 'end_time_t
running_tasks = running_tasks.dropna(subset=['plan_cpu', 'plan_mem'])
# Splitting data into hours
running_tasks['start_hour'] = running_tasks['start_time_task'] // 3600
running_tasks['end_hour'] = running_tasks['end_time_task'] // 3600
```

```
running_tasks = running_tasks[['task_name', 'task_type', 'plan_cpu', 'plan_m
running_tasks
```

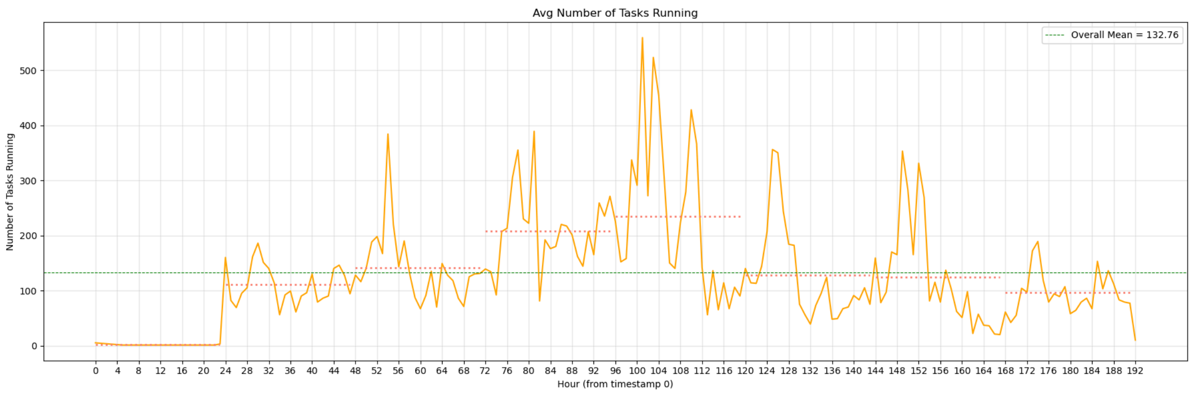
Out[12]:

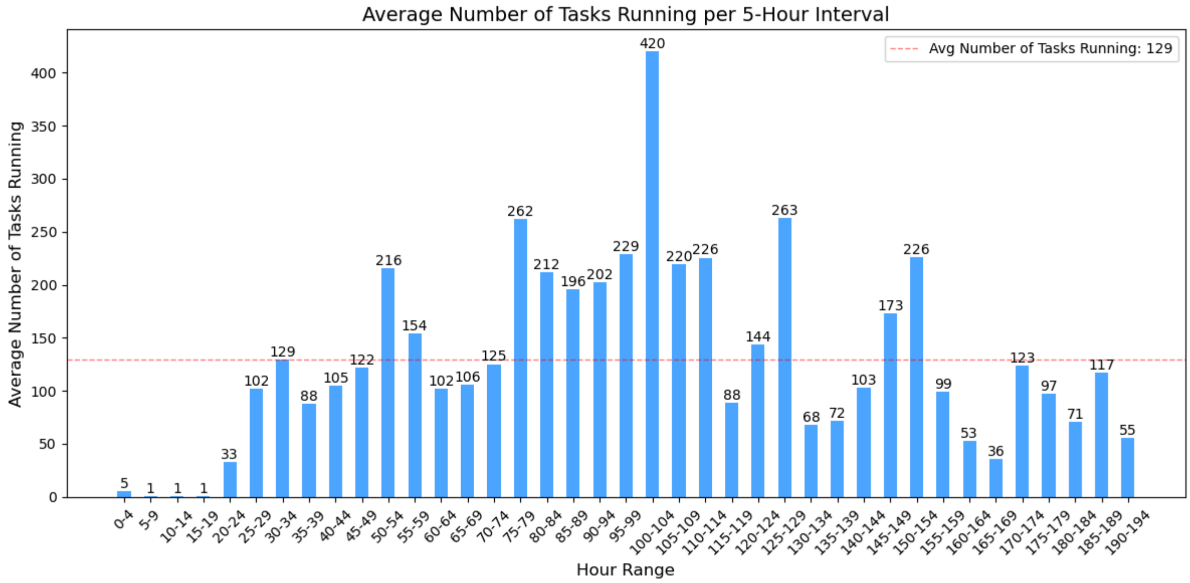
	task_name	task_type	plan_cpu	plan_mem	start_
771712	J5_2_3_4	1	100.0	0.59	
9948906	J5_4	1	50.0	0.59	
10078188	task_NDg2ODM2NDIyMDczNDQ4NzMzOA==	11	700.0	0.40	
10078189	task_NzkwNTc4MjA2ODI2MzE3NzU4MQ==	11	300.0	0.19	
1739122	J13_2_3_4_12	1	100.0	0.49	
...	...	...	...	...	
7950645	J11_6_10	1	50.0	0.39	
7950647	J9_3_4_8	1	50.0	0.39	
7950648	J10_2_9	1	50.0	0.30	
7950651	J14_1_13	1	50.0	0.30	
12661870	task_MTM0ODUxMTY0NjQzMTI1NTc1MQ==	6	30.0	0.05	

92800 rows × 6 columns

In [13]:

```
hourly_tasks = (running_tasks.assign(hour=lambda df: df.apply(lambda row: ra
task_counts = (hourly_tasks.groupby(['hour'])['task_name'].nunique().reset_i
task_counts = task_counts.dropna(subset=['hour', 'num_tasks'])

plot_with_24h_means(data=task_counts, col_name='num_tasks', color='orange',
task_counts['interval'] = (task_counts['hour'] // 5) * 5
interval_avg = task_counts.groupby('interval')['num_tasks'].mean().reset_inc
overall_mean = interval_avg['num_tasks'].mean()

plt.figure(figsize=(12, 6))
bars = plt.bar([f"{int(x)}-{int(x)+4}" for x in interval_avg['interval']], i
plt.axhline(y=overall_mean, color='red', linestyle='--', linewidth=1, label=

for bar in bars:
    plt.text(bar.get_x() + bar.get_width()/2, bar.get_height() + 0.1, f'{rou

plt.title('Average Number of Tasks Running per 5-Hour Interval', fontsize=14
plt.xlabel('Hour Range', fontsize=12)
plt.ylabel('Average Number of Tasks Running', fontsize=12)
plt.xticks(rotation=45)
plt.legend()
plt.tight_layout()
plt.savefig('alibaba_plots/Alibaba_num_tasks_bar')
plt.show()
```





Analysis of batch_instance csv -

In [14]:
```
# Reading 50 million rows
batch_instance = pd.read_csv('batch_instance.csv', nrows=50000000, header=No
                             names=['instance_name','task_name','job_name',
                                    'status','start_time_instance','end_time
                                    'total_seq_no','cpu_avg','cpu_max','mem_

batch_instance = batch_instance[["instance_name", "task_name", "task_type",
batch_instance = batch_instance.dropna(subset=["cpu_avg"])
# 100 is 1 core
batch_instance['cpu_avg'] = batch_instance['cpu_avg'] / 100
batch_instance['cpu_max'] = batch_instance['cpu_max'] / 100
batch_instance.head()
```

Out[14]:

	instance_name	task_name	task_type	start_time_instance	e
0	ins_74901673	task_LTg0MTUwNTA5Mjg4MDkwNjIzMA==	10	673795	
1	ins_815802872	M1	1	158478	
2	ins_564677701	M1	1	372602	
3	ins_257566161	M1	1	372602	
4	ins_688679908	M1	1	372602	

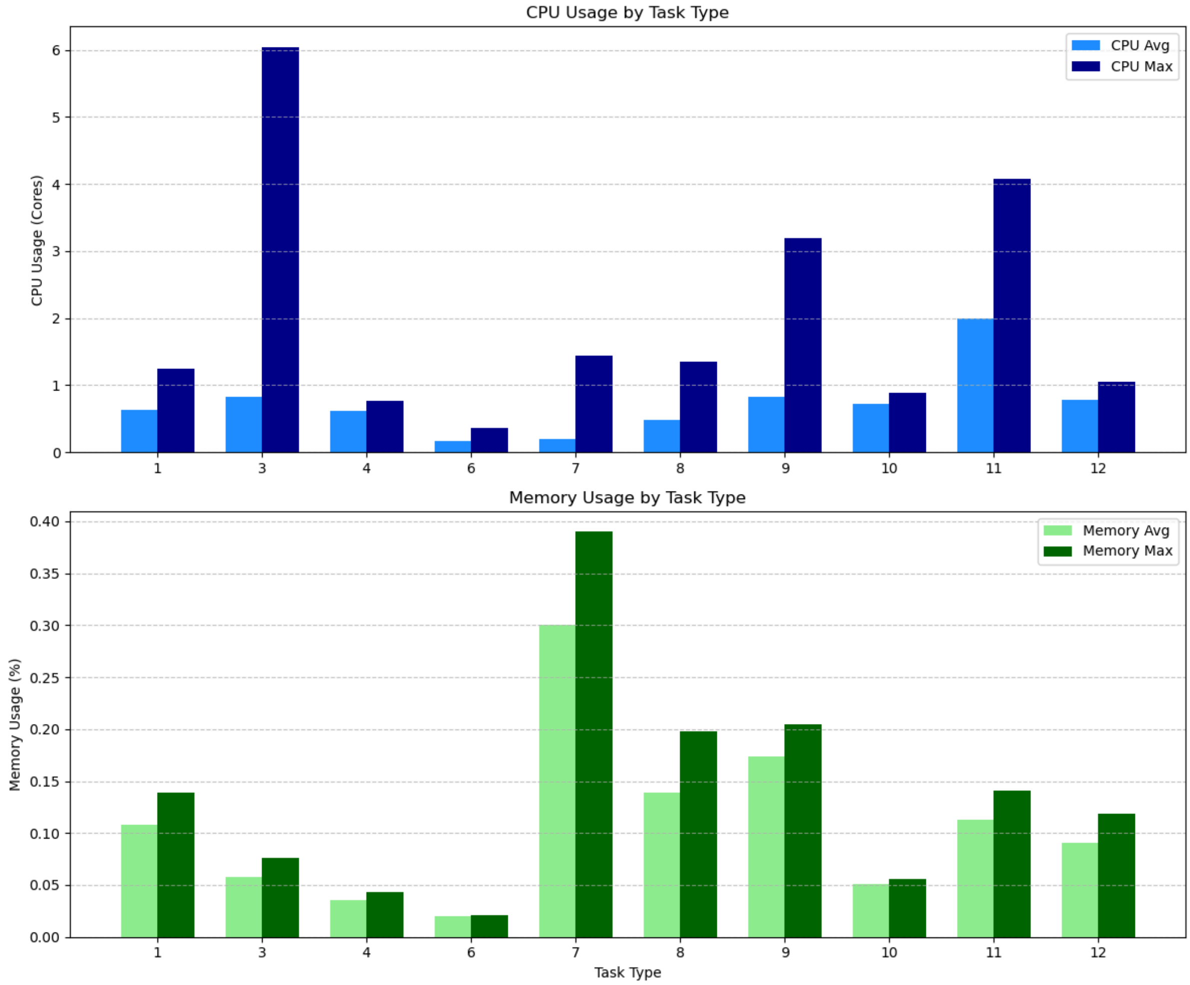
In [15]:
```
task_type_resource_util = batch_instance.groupby('task_type')[['cpu_avg', '
task_type_resource_util
```

Out[15]:

	cpu_avg	cpu_max	mem_avg	mem_max
task_type				
1	0.625219	1.246617	0.107658	0.138465
3	0.824470	6.045977	0.057821	0.075857
4	0.610376	0.762981	0.035789	0.043227
6	0.157893	0.353657	0.020149	0.020979
7	0.190000	1.445000	0.300000	0.390000
8	0.479874	1.343546	0.138819	0.198021
9	0.829633	3.190620	0.173793	0.204449
10	0.723130	0.880720	0.050669	0.055785
11	1.999600	4.079458	0.112568	0.140485
12	0.782905	1.054465	0.090536	0.118951

In [16]:

```
fig, (ax1, ax2) = plt.subplots(2, 1, figsize=(12, 10))
x = np.arange(len(task_type_resource_util.index))
width = 0.35

ax1.bar(x - width/2, task_type_resource_util['cpu_avg'], width, label='CPU A
ax1.bar(x + width/2, task_type_resource_util['cpu_max'], width, label='CPU M
ax1.set_ylabel('CPU Usage (Cores)')
ax1.set_title('CPU Usage by Task Type')
ax1.set_xticks(x)
ax1.set_xticklabels(task_type_resource_util.index)
ax1.legend()
ax1.grid(axis='y', linestyle='--', alpha=0.7)

ax2.bar(x - width/2, task_type_resource_util['mem_avg'], width, label='Memor
ax2.bar(x + width/2, task_type_resource_util['mem_max'], width, label='Memor
ax2.set_xlabel('Task Type')
ax2.set_ylabel('Memory Usage (%)')
ax2.set_title('Memory Usage by Task Type')
ax2.set_xticks(x)
ax2.set_xticklabels(task_type_resource_util.index)
ax2.legend()
ax2.grid(axis='y', linestyle='--', alpha=0.7)

plt.tight_layout()
plt.savefig('alibaba_plots/alibaba_task_resource_usage.png')
plt.show()
```



Predictive Analysis -

In [31]:
```
from xgboost import XGBRegressor
from sklearn.model_selection import train_test_split
from sklearn.metrics import root_mean_squared_error
```

In [32]:
```
data_to_predict = batch_instance[['task_type', 'start_time_instance', 'end_t
data_to_predict = data_to_predict.dropna()
data_to_predict.head()
```

Out[32]:

	task_type	start_time_instance	end_time_instance	machine_id	cpu_avg	cpu_max	men
0	10	673795	673797	m_2637	0.13	0.16	
1	1	158478	158520	m_3430	0.03	0.19	
2	1	372602	372616	m_1910	0.87	1.16	
3	1	372602	372615	m_2485	0.91	1.23	
4	1	372602	372615	m_993	0.93	1.41	

In [33]:
```
data_to_predict["total_time_running"] = data_to_predict['end_time_instance']
data_to_predict["vm_creation_hour_of_day"] = (data_to_predict["start_time_in
training_data_X, testing_data_X, training_data_Y, testing_data_Y = train_tes
```

In [36]:
```
xgboost_regressor_model = XGBRegressor(n_estimators = 1500)
xgboost_regressor_model.fit(training_data_X, training_data_Y)
avg_cpu_prediction_values = xgboost_regressor_model.predict(testing_data_X)
```

```
print(avg_cpu_prediction_values)
root_mean_squared_error(testing_data_Y * 100, avg_cpu_prediction_values * 1(
```

```
[0.44832546 0.6254716  0.26772404 ... 0.6964749  0.69161016 0.5859877 ]
```

Out[36]:

```
23.3734438773299
```

In [ ]:

```
root_mean_squared_error(testing_data_Y * 100, avg_cpu_prediction_values * 1(
```

In [37]:

```
diff_in_prediction_vals_from_truth = (abs(avg_cpu_prediction_values - testi
prediction_in_range_counter = 0
for curr_diff in diff_in_prediction_vals_from_truth:
    if curr_diff <= 0.1:
        prediction_in_range_counter = prediction_in_range_counter + 1
model_avg_cpu_pred_accuracy = prediction_in_range_counter * 100 / len(diff_:
print("Model's Average CPU Utilization Precition accuracy is:", str(model_a
```

```
Model's Average CPU Utilization Precition accuracy is: 52.53613085850801%
```

In [ ]:

```
training_data_X, testing_data_X, training_data_Y, testing_data_Y = train_te:
```

In [39]:

```
xgboost_regressor_model = XGBRegressor(n_estimators = 1500)
xgboost_regressor_model.fit(training_data_X, training_data_Y)
avg_mem_prediction_values = xgboost_regressor_model.predict(testing_data_X)
print(avg_mem_prediction_values)
```

```
[0.10824015 0.03754018 0.05664064 ... 0.02165665 0.06909399 0.05594576]
```

In [42]:

```
root_mean_squared_error(testing_data_Y, avg_mem_prediction_values)
```

Out[42]:

```
0.18460717351350522
```

In [43]:

```
diff_in_prediction_vals_from_truth = (abs(avg_mem_prediction_values - testi
prediction_in_range_counter = 0
for curr_diff in diff_in_prediction_vals_from_truth:
    if curr_diff <= 0.1:
        prediction_in_range_counter = prediction_in_range_counter + 1
model_avg_mem_pred_accuracy = prediction_in_range_counter * 100 / len(diff_:
print("Model's Average Memory Utilization Precition accuracy is:", str(mode]
```

```
Model's Average Memory Utilization Precition accuracy is: 87.7180733480407
2%
```